Walter W. Bradley.

1868

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 39 JANUARY 1943 No. 1

CALIFORNIA JOURNAL
OF
MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXIX

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

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State Mineralogist

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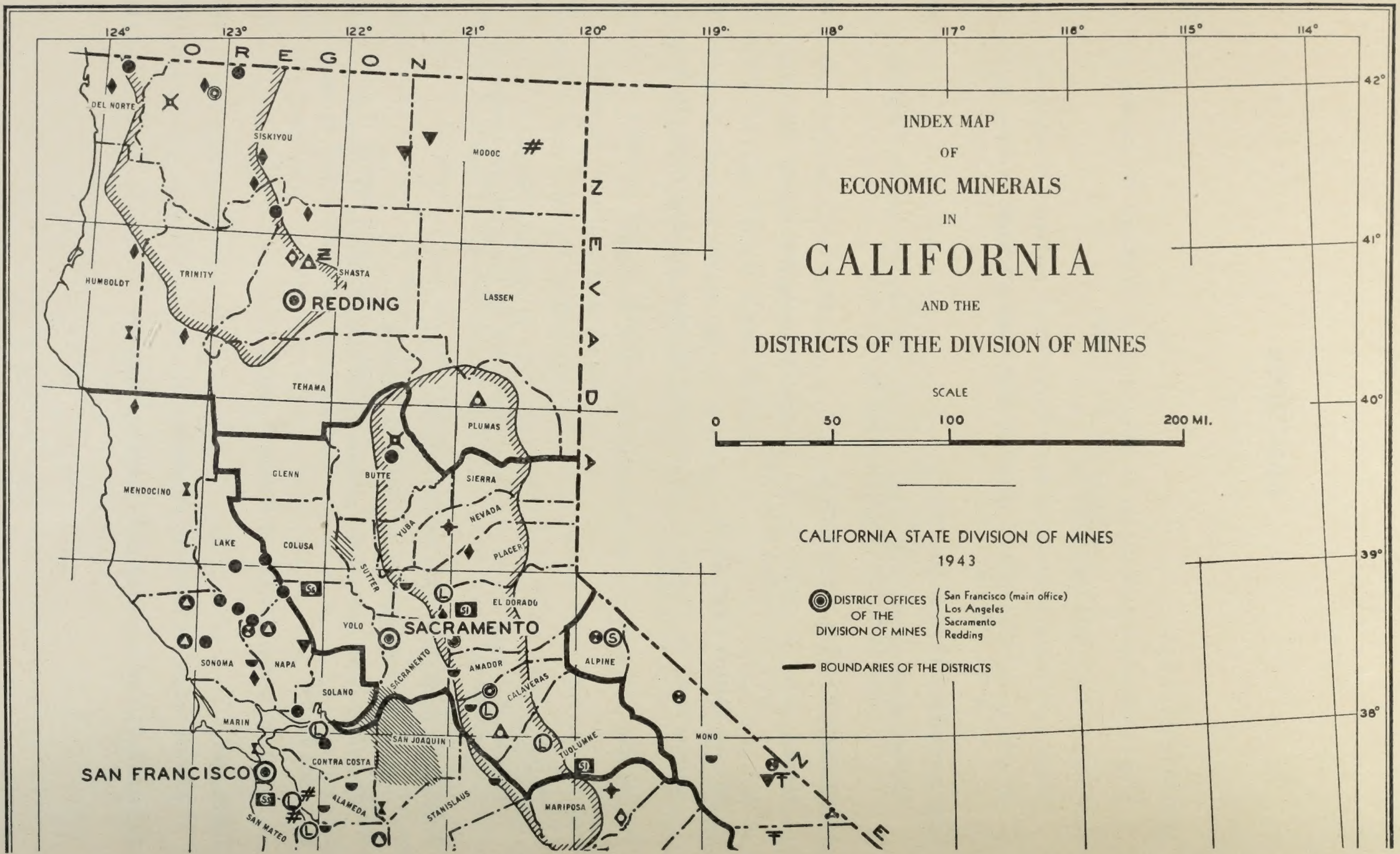
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BUTTE
SIERRA
MENDOCINO
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YUBA
LAKE
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PLACER
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YOLO
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ALPINE
SONOMA
NAPA
AMADOR
SACRAMENTO
SOLANO
CALAVERAS
MARIN
SAN JOAQUIN
MONO
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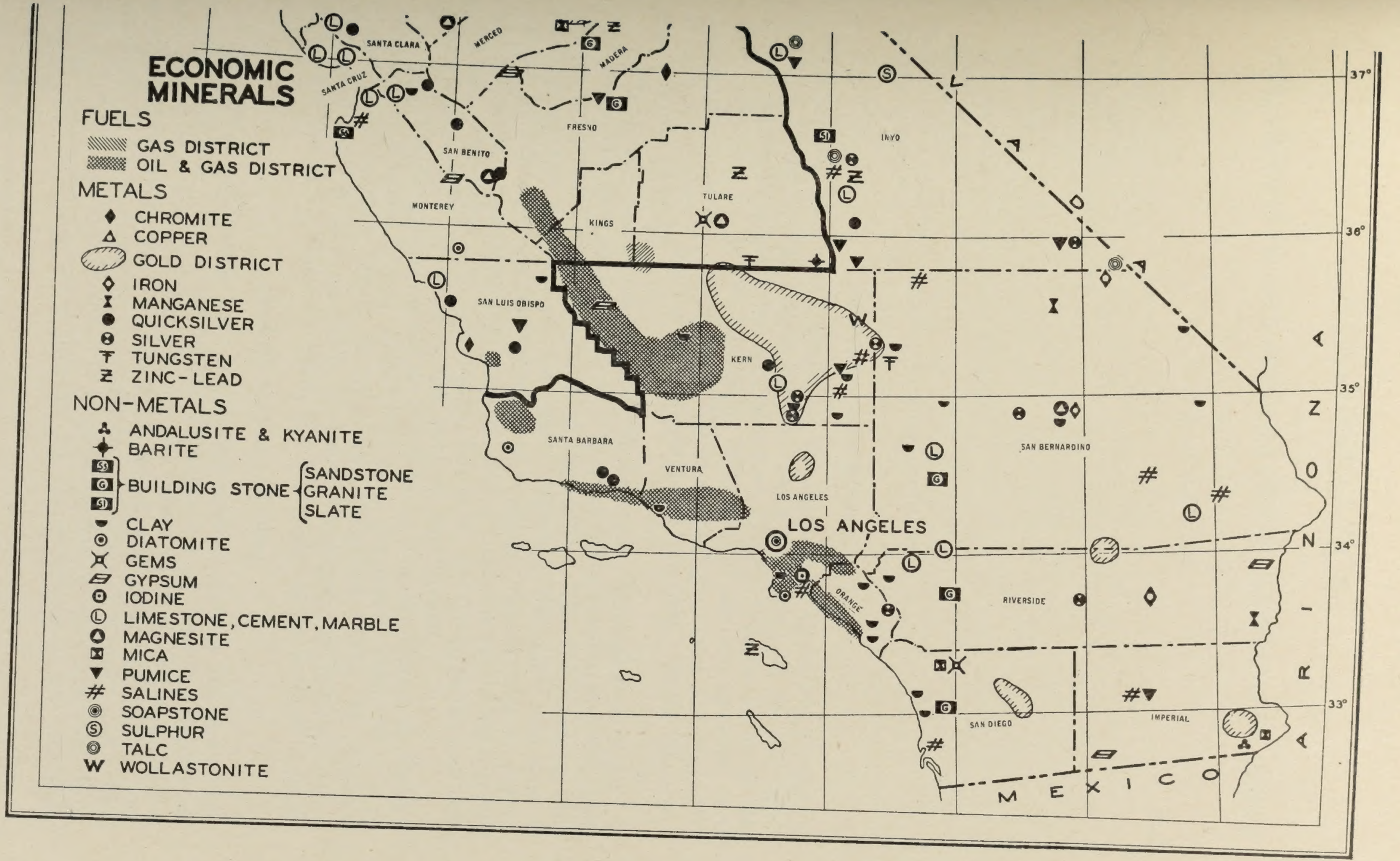
INDEX MAP
OF
ECONOMIC MINERALS
IN
CALIFORNIA
AND THE
DISTRICTS OF THE DIVISION OF MINES

CALIFORNIA STATE DIVISION OF MINES
1943

◎ DISTRICT OFFICES OF THE DIVISION OF MINES: San Francisco (main office), Los Angeles, Sacramento, Redding

━ BOUNDARIES OF THE DISTRICTS


ECONOMIC MINERALS
FUELS
▨ GAS DISTRICT
▨ OIL & GAS DISTRICT
METALS
◆ CHROMITE
△ COPPER
GOLD DISTRICT
◇ IRON
MANGANESE
● QUICKSILVER
SILVER
TUNGSTEN
Z ZINC-LEAD
NON-METALS
ANDALUSITE & KYANITE
BARITE
SS G Sl BUILDING STONE SANDSTONE GRANITE SLATE
CLAY
⊙ DIATOMITE
GEMS
GYPSUM
IODINE
Ⓛ LIMESTONE, CEMENT, MARBLE
MAGNESITE
MICA
▼ PUMICE
# SALINES
◉ SOAPSTONE
Ⓢ SULPHUR
◎ TALC
W WOLLASTONITE
SANTA CLARA
SANTA CRUZ
MERCED
MADERA
FRESNO
SAN BENITO
MONTEREY
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
LOS ANGELES
SAN BERNARDINO
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
NEVADA
ARIZONA
MEXICO
37°
36°
35°
34°
33°

ADMINISTRATION

ORGANIZATION AND SERVICE OF THE DIVISION OF MINES

By Walter W. Bradley*

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HISTORY AND PURPOSE

April 16, 1880 was marked by the signing by Governor George C. Perkins (later United States Senator for California) of the bill introduced in the legislature by Assemblyman Joseph Wasson of Mono and Inyo counties, by which the State Mining Bureau was created, with headquarters in San Francisco. Under authority of that act, Henry G. Hanks was shortly thereafter commissioned the first ''State Mineralogist'' of California.

Previously there had been two short-lived ''geological surveys'' in this state; the first under John B. Trask as State Geologist, 1853-1856; the second under Josiah D. Whitney, 1860-1873. The fundamental idea underlying the creation of the State ''Mining Bureau'' was that it should be concerned primarily with an economic developmental survey of California's mineral resources and their utilization rather than solely geology. Provision was also made, however, in the organic act that geology should be included in the work of the bureau.

The following have served as State Mineralogist: Henry G. Hanks, 1880-1886; William Irelan, 1886-1893; J. J. Crawford, 1893-1897; A. S. Cooper, 1897-1901; Lewis E. Aubury, 1901-1911; Wm. H. Storms, December 1911-February 1913; Fletcher Hamilton, 1913-1923; Lloyd L. Root, February 1923-July 1928; the incumbent since August 1, 1928.

PRESENT ORGANIZATION

By enactment at the 1927 legislative session, Article IIj was added to the Political Code creating the Department of Natural Resources, and providing for the transfer of the State Mining Bureau to the new department as the ''Division of Mines and Mining.'' This was amended in 1929, changing the name to ''Division of Mines'' and creating a ''State Mining Board'' to consist of five members whose duty it is to determine ''general policies for the guidance of the Division of Mines.''

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* State Mineralogist.

In addition to the main headquarters with offices in the Ferry Building, San Francisco, including the library, laboratory, and mineral exhibits, district mining engineers are stationed at offices in Sacramento, Los Angeles, and Redding. Reports and bulletins to a total number of more than 160 have been published from time to time describing in detail (with maps, charts, and photographs) the varied mineral substances available in this great commonwealth of California—their location, character, transportation, and other pertinent data. In 1929, by appropriation, definite provision was made for geological investigations, reports, and maps. This provision continues, and has become an important feature of the Division's activities.

PUBLIC SERVICES

Advisory and Educational

All services of the Division to the public and the mineral industries are fundamentally advisory and educational. The work of the Division is essentially that of an information bureau; inventories are made, and files and catalogues of the state's diversified mineral resources are maintained. The public is kept informed by various publications, by personal interviews, by correspondence, by personal appearances of members of the staff before educational and other organizations, such as clubs, chambers of commerce, lodges, and industrial groups.

Publications

Printed publications of the Division of Mines are sold at prices sufficient only to cover the cost of printing and distribution; but, in addition, these publications are furnished, without charge, to libraries, schools, and colleges, and are exchanged with similar governmental surveys, state, federal, and foreign.

Library

In addition to the Division's reports, the library contains complete files of the reports of the federal Geological Survey and Bureau of Mines; also of many geological surveys of other states and foreign countries; technical magazines such as the Engineering and Mining Journal, Mining and Scientific Press, and Petroleum World [1]; as well as several thousand volumes on mineralogy, geology, mining, chemistry, metallurgy, and allied subjects. These are available for reference use by the public during office hours, daily except Sundays, holidays, and Saturday afternoons.

Exhibits

The nucleus each of the library and mineral exhibits was the collection of the California State Geological Society, organized in 1877. This collection was donated to the State Mining Bureau on its creation in 1880. The present exhibits show, in addition to specimens of nearly all minerals occurring in California (both of mineralogic and economic interest), typical specimens from practically every country in the world. The collection is invaluable for commercial comparisons as well as for scientific study. It is the largest exhibit of its kind west of the Mississippi River, and ranks fifth in the United States.

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[1] For a more complete list of newspapers, periodicals, and recent accessions to the Library, see the report by H. G. Hubbard, Librarian, on pages 106-110.

Mineral Identification

The laboratory is maintained for qualitative testing and identification of mineral samples sent from any locality in California. Information is given as to possible commercial value and uses. No quantitive analyses nor assays are made. That is left to commercial firms; but many dollars that might be spent on unnecessary assays are saved our citizens by the qualitative identification service.

Current Notes on Commercial Minerals

One of the most useful services of the Division, and productive of helpful, practical results, was started in 1923 with the issuing of a mimeographed sheet monthly listing mineral properties or tonnages for sale or lease, or wanted by persons or firms that had registered their desires in this office. Brief statements of these facts are listed by key number, but names and addresses must be obtained at our headquarters or a branch office of the Division. This service helps to bring seller and buyer together. As names are not published in the monthly notes as issued, inquiries must be cleared through the Division's offices, thus permitting our staff to keep in touch with developments, and acquainted with items for which there is demand.

Licenses for Gold Buyers

As a means of minimizing the stealing of gold (''high-grading'') from the mines, the Ore Buyers License Act was passed in 1925. This gives a control over the avenues through which gold is sold or transferred to the smelter and the U. S. Mint. A license to purchase must be obtained from the State Mineralogist. Records must be kept and copies transmitted to the State Mineralogist showing the source of the gold, the name and location of the mine, and name and address of the seller. The nominal fees charged for the licenses cover, in part, the cost of maintaining inspection.

Employment

While the Division does not conduct a regular employment service, members of the staff gladly advise those seeking technical engagements with mine operators, and we maintain a file specifying qualifications and experience of those whose names have been registered with us. Occasionally inquiries are received for men to fill certain types of positions in mine operations. We have also assisted in filling personnel requests for geologists and paleontologists with governmental agencies, oil companies, and other organizations.

COOPERATION WITH FEDERAL AGENCIES AND OTHER ORGANIZATIONS

Whole-hearted cooperation has been built up between the Division of Mines and several of the federal agencies, particularly the United States Geological Survey, the United States Bureau of Mines, the

United States Forest Service, and more recently the Reconstruction Finance Corporation, War Production Board, and Metals Reserve Company. Specifically in the present war emergency, the Division is acting as the liaison for California's mine operators and the Emergency Coordinator for Mines of the W. P. B. in the matter of priorities. Also, we are handling the field reports for the R. F. C. on applications for Preliminary Development Loans.

Close cooperation is maintained with the United States Geological Survey and Bureau of Mines, as well as the geological departments of the several universities of the state, in coordinating studies of the geological formations and their mineral resources. Valuable cooperation also obtains with the California Academy of Sciences, American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, mining and oil companies, technical magazines, and consulting engineers and geologists. Contributions from these groups have been noteworthy, to the quarterly issues of the State Mineralogist's Report (California Journal of Mines and Geology), to various maps (in particular the Geologic Map of California), and to bulletins issued by the Division, in particular Bulletin 118 (Geologic Formations and Economic Development of the Oil and Gas Fields of California).

CURRENT PROGRESS

Present activities of the Division, both as related to field work and consequent publications, are principally tied in with the war emergency and the program to obtain greater production of all war-needed metals and other mineral supplies. Maps have recently been issued on quicksilver, petroleum, chromite, and tungsten resources of California, and one on manganese is in press. Reports are now available on quicksilver, chromite, and tungsten, and a bulletin on manganese is nearly ready for the printer. Preprints of Parts One and Two of Bulletin 118 on the petroleum industry are available, and Parts Three and Four, completing the volume, will shortly be received from the printer, after which the bound volume will be made available. There have been no additions to the personnel of the Division during the past three months.

SAN FRANCISCO FIELD DISTRICT

MINES AND MINERAL RESOURCES OF SANTA CRUZ COUNTY

By Henry G. Hubbard*

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INTRODUCTION

One of the original 27 counties created February 18, 1850, Santa Cruz County was first called Branciforte.[1] An amendment passed later during the first session of the legislature gave it the name Santa Cruz (Holy Cross), derived from the cross marking the site of Santa Cruz Mission founded in 1791 by Padres Lopez and Salzar. However, the first settlers came to this area with the Portola expedition in October 1769. With the exception of its northern boundary, which originally extended from the ocean due east through a point at the head of San Francisquito Creek to the summit of the Santa Cruz Mountains, the original boundaries of the county were the same as they are at present. In 1868 the northern line was moved southward and a portion of what had been Santa Cruz County was annexed to San Mateo, which had been created in 1856. The new dividing line began on the ocean shore near Point Año Nuevo (New Year), thence bearing northeastward to the summit of the mountains in a broken line of east- and north-trending segments. Since this move in 1868 the county's boundaries have remained unchanged.

GEOGRAPHY

Santa Cruz County, floral gem by sapphire sea, borders on Monterey Bay and the Pacific Ocean, its curving coast-line extending from the mouth of Pajaro (Bird) River where it enters the bay, northwestward for 40 miles. San Mateo County bounds it on the north; Santa Clara County lies to the northeast, and Monterey and San Benito Counties adjoin on the south.

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* Junior Mining Engineer, Division of Mines, San Francisco Field District.

[1] Coy, Owen C., California county boundaries: California Hist. Survey Comm., pp. 248-249, Berkeley, 1923.

The area of this colorful county is only 435 square miles, making it, exclusive of the city and county of San Francisco, the smallest county in the state. Its population is 45,057 (1940 census). The city of Santa Cruz, the county seat, situated on the north shore of blue Monterey Bay, is one of the most attractive seaside resorts of California. It is noted for its equable climate and long silver strand of bathing beach bordering the green and golden hills of California; and it is easily reached from San Francisco, to the north, by air, rail, or highway. The latter route is 73 miles.

The county is served by a line of the Southern Pacific railroad from Watsonville, the second city in size and principal shipping center of the rich Pajaro Valley; this railroad runs northwestward along the coast via Santa Cruz to the plant of the Santa Cruz Portland Cement Company at Davenport. Another branch northerly from Santa Cruz city follows the San Lorenzo River and its tributary, Zayante Creek, to serve the two sand-pit operations near Olympia (see under Stone Industry). This line formerly extended to Los Gatos in Santa Clara County. United Air Lines schedules daily two-way flights between Los Angeles and San Francisco which stop at Del Monte, in Monterey County, half way around the Monterey Bay shore from Watsonville.

A municipal pier at Santa Cruz permits the docking of ocean-going vessels. Good highways and motor-bus service make the county readily accessible to motorists.

Pajaro Valley is noted as an apple-growing district. The cultivation of fruits, berries, and vegetables, and the operation of packing plants and canneries are the principal industries. Poultry raising, commercial fisheries, and mining are also important. The latter industry, however, is confined almost entirely to the production of nonmetallic structural and industrial minerals.

TOPOGRAPHY

The greater part of Santa Cruz County is rugged and mountainous. Castle Rock Ridge, which forms the eastern boundary, trends in a northwest direction, approximately parallel to the coast line at an average distance of 20 miles inland. It rises to elevations of more than 3000 feet, and forms an escarpment with a steep northeastern slope on the Santa Clara County side. To the southeast, between the summit and the ocean, the slope is more gradual, but the region is cut by many deep gulches formed by streams flowing westward to the sea.

Ben Lomond Mountain, which rises to an elevation of more than 2000 feet, between Castle Rock Ridge and the ocean, also presents a steep escarpment to the northeast and a long gentle slope on the southwest to the ocean. The parallel arrangement of valleys and ridges characteristic of much of the Coast Ranges is not prominently developed in this county. Old sea terraces are noticeable at many places along the coast. The hillsides are generally deeply soil-covered and unusually steep, there being many V-shaped canyons in the Monterey shale areas.

In the region of San Lorenzo River and Boulder Creek the hills are heavily wooded, and several redwood groves contain gigantic trees that are centuries old. The drainage basin of San Lorenzo River includes nearly one-third of the county. Pajaro River drains the southern portion, flowing westward and forming the south boundary of the county. Numerous small perennial streams flow down the west side of Ben Lomond Mountain to the sea.

GEOLOGY

The Santa Cruz quadrangle, the geology of which has been mapped and described in the Santa Cruz folio,[2] includes the greater portion of the county. The reader is referred to this folio for a detailed geological history of the area and description of the formations. Reference should also be made to the geologic map of California[3] and to Bulletin 118[4] of the Division of Mines.

That half of the county lying northwest of the old Southern Pacific right of way between Los Gatos and Santa Cruz (excluding only the Ben Lomond Mountain block) and Castle Rock Ridge along the eastern boundary is composed of Tertiary (Miocene) marine sandstones and diatomaceous shales. The area east of Santa Cruz and extending to the base of Castle Rock Ridge is also composed of Tertiary (Pliocene) sedimentary formations, including marine and freshwater sandstones, shales, and gravels. Quaternary sands, gravels, and clays predominate along the southern boundary and Pajaro River Valley. Ben Lomond Mountain is an upward-tilted granitic block, the core of which is quartz diorite. The block also contains relatively small areas of metamorphic schist, marble, and limestone. All of the sedimentary formations have been much folded, crushed, and broken, and numerous faults have been noted, including the San Andreas which approximates the northeastern boundary of the county.

MINERAL RESOURCES

Records covering the variety, amount, and value of the minerals produced in Santa Cruz County extend no farther back than 1894, but there was considerable production before that time, especially of gold, bituminous rock, limestone, and lime.

Although it was 44 years after the organization of the county and 46 years after mining became an established industry in the state that any segregated county record of output was begun, in the succeeding 48-year interval (1894 to 1941 inclusive), the total recorded value of minerals produced amounted to $88,329,232. This large total includes no metals except a negligible amount of magnetite (iron ore) from black sand, and a nominal gold item; no petroleum, the most valuable nonmetallic found in the state; and no ''war minerals,'' the production of which materially increased the mineral output of many of the counties from 1915 to 1918, and from 1940 to the present date.

In 1924 the mineral output of Santa Cruz County was valued at $4,339,233, giving it tenth place among the 58 counties of the state. In 1940 it placed nineteenth in this respect with a total production value of $2,779,306, having declined from the 1939 figure of $3,140,742.

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[2] Branner, J. C., Newsom, J. F., and Arnold, Ralph, Description of the Santa Cruz quadrangle, Cal.: U. S. Geol. Survey Geol. Atlas, Santa Cruz folio (no. 163), 11 pp., 1909.

[3] Jenkins, Olaf P., Geologic Map of California, Scale 1 :500,000: California Div. Mines 1938.

[4] Taliaferro, N. L., Geologic history and structure of the central Coast Ranges of California: California Div. Mines Bull. 118, pp. 119-163, 1943.

TABLE 1—MINERAL PRODUCTION

Year	Lime		Limestone	
	Barrels	Value	Tons	Value
1894	167,000	$138,200	4,000	$5,000
1895	145,000	133,750	12,055	12,055
1896	116,000	95,500	27,827	28,663
1897	149,600	111,800	10,688	8,005
1898	151,000	151,000	7,912	5,738
1899	161,893	176,893	4,135	3,730
1900	163,985	131,288	1,669	1,213
1901	161,500	161,500	3,845	3,595
1902	185,223	161,302	1,850	1,850
1903	220,835	185,442	3,000	2,725
1904	293,207	306,775	[2]	----
1905	218,084	199,974	7,325	52,125
1906	255,469	347,490	11,431	55,242
1907	213,599	241,179	6,370	6,000
1908	119,996	119,996	1,178	2,167
1909	228,875	296,785	3,457	5,273
1910	214,137	230,513	4,361	6,770
1911	216,508	206,225	22,622	44,591
1912	169,646	159,505	7,307	7,553
1913	75,000	60,000	39,494	30,994
1914	173,282	157,011	14,666	25,082
1915	191,643	177,873	2,047	4,873
1916	176,263	225,485	4,318	9,820
1917	213,104	173,778	6,527	11,378
1918	182,083	285,316	7,132	15,313
1919	150,271	234,039	5,527	12,690
1920	141,633	202,908	5,062	20,101
1921	122,907	242,869	[2]	----
1922	174,490	235,802	4,581	20,534
1923	157,660	203,632	6,733	14,242
1924	127,830	212,540	[2]	----
1925	165,340	224,724	16,551	33,102
1926	154,570	227,904	----	----
1927	134,310	173,207	16,717	38,045
1928	121,290	135,991	8,600	24,849
1929	100,750	112,761	15,143	40,786
1930	[2]	----	11,405	46,925
1931	[2]	----	9,383	34,430
1932	[2]	----	6,330	15,292
1933	[2]	----	6,413	22,587
1934	[2]	----	[2]	----
1935	[2]	----	[2]	----
1936	[2]	----	[2]	----
1937	[2]	----	13,043	45,754
1938	[2]	----	[2]	----
1939	[2]	----	34,873	47,529
1940	[2]	----	30,807	73,875
1941	[2]	----	19,937	96,878
Totals	[2]6,113,983	$6,606,998	[2]426,321	$1,134,713

[1] Includes crushed rock, rubble, sand, gravel.
[2] See under 'Unapportioned.'

OF SANTA CRUZ COUNTY, 1894–1941

Bituminous rock		Miscellaneous stone[1], value	Miscellaneous and unapportioned		
Tons	Value		Amount	Value	Substance
20,782	$79,980	-----	-----	-----	
32,067	102,486	$4,000	75 M	$375	Brick.
43,843	109,536	4,000	497 M	2,485	Brick.
43,179	123,056	-----	300 M	1,500	Brick.
40,598	113,898	-----	-----	-----	
27,503	70,569	200	-----	-----	
21,960	58,590	-----	-----	-----	
13,580	30,654	-----	10 tons	30	Clay.
31,700	41,084	-----	106 tons	1,060	Asphalt.
18,426	45,190	20,750	700 cu.ft.	140	Granite.
[2]	-----	2,925	-----	-----	
17,583	42,500	1,750	-----	-----	
13,544	38,860	3,500	-----	-----	
21,955	64,707	14,800	-----	-----	
25,041	85,123	19,736	450 cu. ft. 28,400 tons	336 28,400	Granite. Clay.
31,392	110,067	20,717	63,541 tons -----	13,800 1,794,294	Clay. Unapportioned, 1900-1909.
35,565	124,195	23,425	52,970 tons -----	15,981 2,096,031	Clay. Unapportioned.
24,815	80,371	7,627	-----	2,448,339	Unapportioned.
32,146	80,439	22,710	-----	879,437	Other minerals.
26,932	67,330	10,511	-----	1,647,970	Unapportioned.
40,540	115,500	4,276	-----	1,341,089	Unapportioned.
17,399	60,728	6,794	-----	1,331,263	Unapportioned.
[2]	-----	2,815	-----	1,440,991	Cement, marble, bituminous rock.
[2]	-----	2,368	-----	1,480,800	Cement, potash, bituminous rock.
[2]	-----	9,107	-----	2,599,717	Cement, potash, bituminous rock.
[2]	-----	17,074	-----	1,981,253	Other minerals.
[2]	-----	23,379	-----	2,834,750	Bituminous rock, cement, iron ore, mineral paint, potash.
[2]	-----	22,895	-----	3,815,121	Bituminous rock, cement, limestone, mineral paint, potash.
[2]	-----	7,398	-----	3,345,071	Cement, bituminous rock, potash.
[2]	-----	15,363	-----	3,992,668	Cement, bituminous rock, potash.
[2]	-----	29,217	-----	4,097,476	Cement, bituminous rock, potash, limestone.
[2]	-----	21,125	-----	2,948,085	Bituminous rock, cement.
[2]	-----	26,361	----- ----- -----	143 1 3,249,785	Gold. Silver. Bituminous rock, cement, limestone.
[2]	-----	45,570	-----	3,216,387	Bituminous rock, cement.
-----	-----	62,571	-----	3,100,509	Bituminous rock and cement.
-----	-----	75,250	-----	3,098,836	Bituminous rock and cement.
-----	-----	79,218	-----	2,235,811	Bituminous rock, cement, iron ore, lime.
-----	-----	98,881	-----	1,633,823	Bituminous rock, cement, coal, lime.
-----	-----	34,253	-----	998,221	Bituminous rock, cement, lime.
-----	-----	14,120	----- 3 oz. -----	307 1 1,197,165	Gold. Silver. Bituminous rock, cement, lime.
-----	-----	84,744	----- 2 oz. -----	130 1 1,711,969	Gold. Silver. Bituminous rock, cement, coal, iron ore, lime, limestone.
[2]	-----	78,743	----- ----- -----	617 6 1,454,067	Gold. Silver. Bituminous rock, cement, lime, limestone, marble.
[2]	-----	128,407	-----	1,974,715	Bituminous rock, cement, gold, lime, limestone, silver.
[2]	-----	[2]	-----	2,028,709	Bituminous rock, cement, lime, miscellaneous stone.
[2]	-----	91,422	----- ----- -----	350 1 1,815,415	Gold. Silver. Bituminous rock, cement, iron ore, lime, limestone.
[2]	-----	305,417	----- -----	70 2,787,726	Gold. Bituminous rock, cement, iron ore, lime.
[2]	-----	141,602	----- ----- -----	665 4 2,563,160	Gold. Silver. Bituminous rock, cement, iron ore, lime.
[2]	-----	173,728	----- ----- -----	315 2 2,989,805	Gold. Silver. Bituminous rock, cement, iron ore, lime.
[2]580,550	[2]$2,225,363	[2]$1,738,749	-----	$76,197,088	

As will be noted by referring to the table of mineral production, the variety of commercial minerals is small and practically confined to the structural materials, bituminous rock, cement, clay, lime, limestone, sand, gravel, and crushed rock. A number of other minerals are known to occur in the county, but they are of minor importance at their present stage of development. Among these are coal, gold, granite, iron, mineral water, and petroleum. Still others, mainly of mineralogical interest are amphibole (called mountain leather), arsenopyrite, calcite, cinnabar, graphite, gypsum, melanterite, and talc. Magnetite, chromite, ilmenite, garnet, olivine, zircon, quartz, and platinum are constituents of some of the beach sands.

Further development may place some of these on the commercial list, but the future production of Santa Cruz County will no doubt continue in large part to be made up of the common structural and industrial nonmetallics which have contributed most to its mineral production in the past.

The last general report on the mineral resources of the county is contained in the Twenty-second Report of the State Mineralogist.[5] The oil possibilities are discussed in Bulletins 89 [6] and 118 [7] of the Division of Mines.

Santa Cruz County was visited by the writer in January, 1943. New developments, corrections, and changes noted since the former reports are herein published, and also a map of the county showing mines and quarries.

The courteous assistance rendered by local chamber of commerce officials, county officers, property owners, and operators is gratefully acknowledged.

Table 1 [8] gives the total recorded output 1894-1941, inclusive.

DESCRIPTIONS OF PROPERTIES

Bituminous Rock

The deposits of asphaltic and bituminous rock in Santa Cruz County have long been known and utilized. The material is a porous, loose, fine- to fairly coarse-grained sandstone, impregnated with asphaltum. These so-called bituminous rock deposits are extensive, but they have been developed at only a few places. They are described in the Santa Cruz folio.[9]

> "The bituminous rocks are sandstone beds lying near the base of the diatomaceous shale, which is referred to as the Monterey. Most of the sandstone beds which immediately underlie or are intercalated with the diatomaceous shale of this locality are more or less bituminous. The structure is monoclinal, with a gentle southwest dip, hence the asphaltic-bearing strata crop out along the sides of the south-westward-flowing streams, where these have cut down nearly or quite to the bottom of the shale.
>
> "The zone of the bituminous rock is exposed near the base of the diatomaceous shale from Santa Cruz northwestward as far as the western side of the Big Basin, a distance of more than 20 miles. Throughout this distance the dip of the lower part of the diatomaceous shale and of the immediately underlying sandstone is gently to the west and southwest. At many places through this district the sandstone beds are more or less bituminous, but at only one locality have they been found to be of commercial value."

---

[5] Laizure, C. McK., Santa Cruz County: California Min. Bur. Rept., vol. 22, no. 1, pp. 68-93, January 1926.

[6] Vander Leck, Lawrence, Petroleum resources of California: California Min. Bur. Bull. 89, pp. 66-68, July 1921.

[7] Tabulated data on wells drilled outside of the principal oil and gas fields: California Div. Mines Bull. 118, p. 660, 1943.

[8] Symons, Henry H., California Mineral production and directory of mineral producers for 1941: California Div. Mines Bull. 122, pp. 250-251, 1943.

[9] Branner, J. C., Newsom, J. F., and Arnold, Ralph, Description of the Santa Cruz quadrangle, Cal.: U. S. Geol. Survey Geol. Atlas, Santa Cruz folio (no. 163), p. 11, 1909.

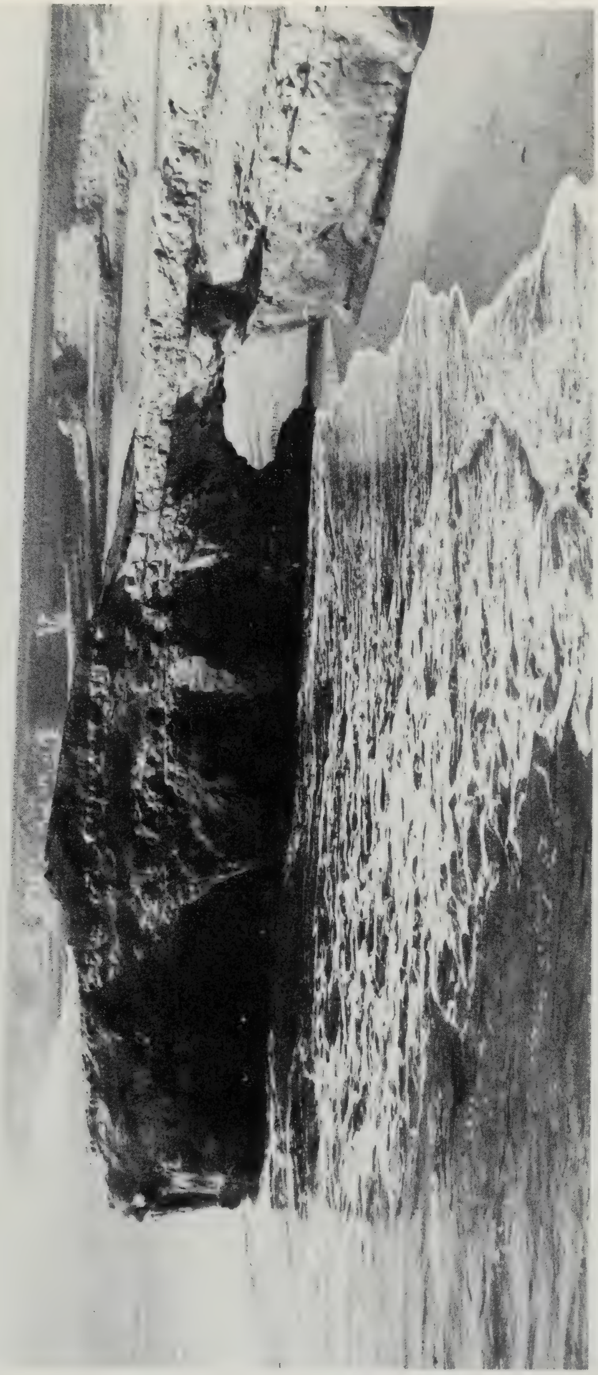

FIG. 1. Swanton Beach (State Natural Bridges Beach), Santa Cruz County.

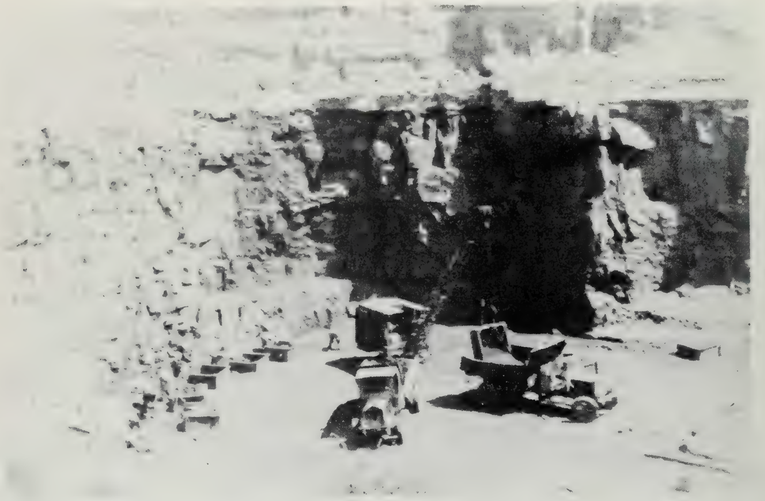

FIG. 2. Calrock Asphalt Company quarry. *Photo by Robert A. Harker.*

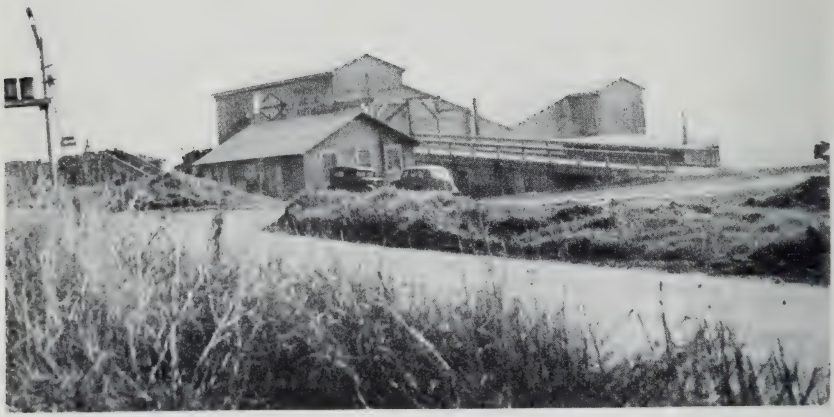

FIG. 3. Calrock Asphalt Company plant at Majors.

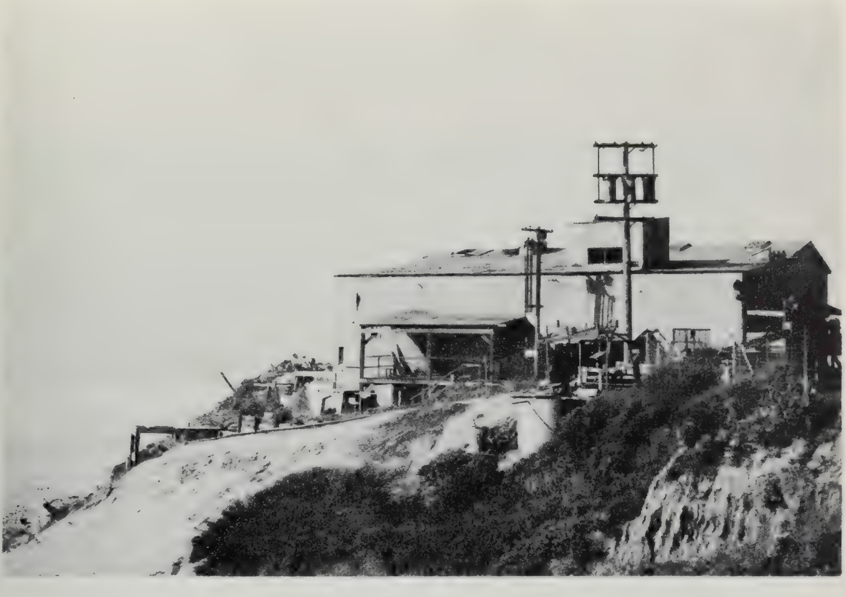

FIG. 4. Old Triumph Steel Company plant at Aptos black sand deposit.

FIG. 5. Neary Ranch clay deposit at Santa Cruz.

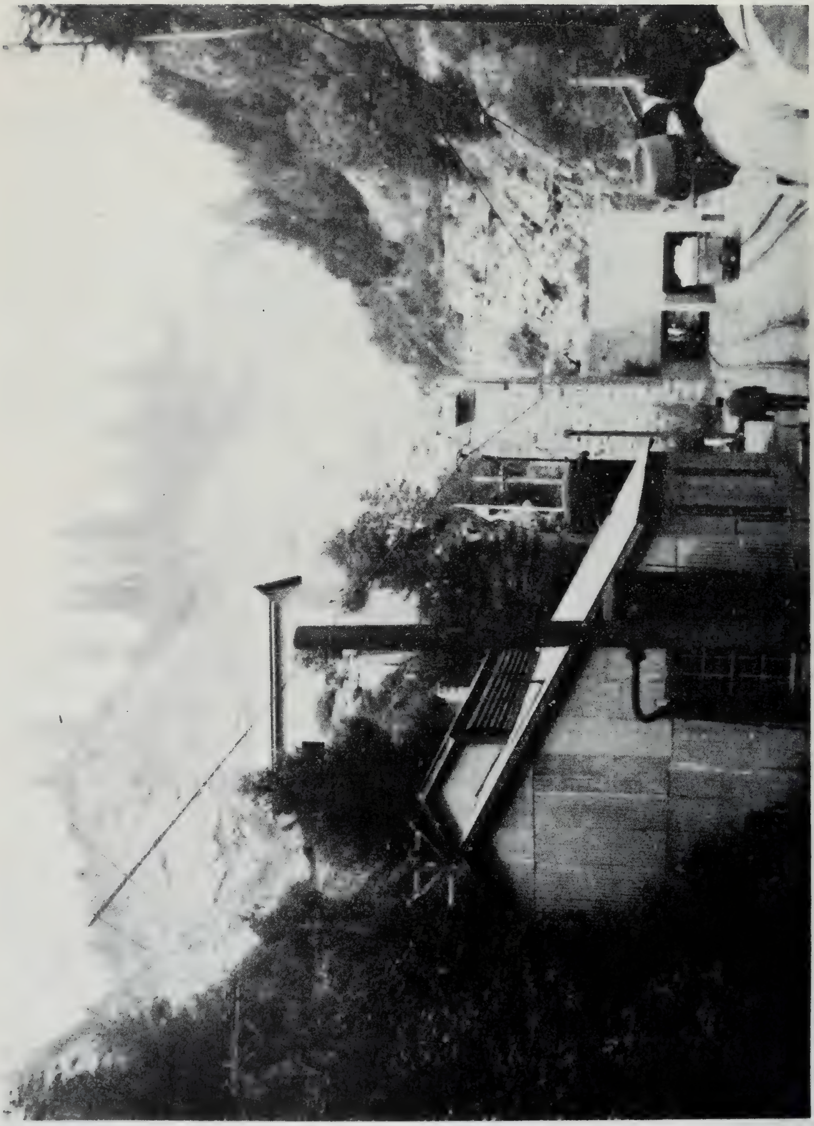

FIG. 6. Limestone quarry of Santa Cruz Portland Cement Company. *Photo by Olaf P. Jenkins.*

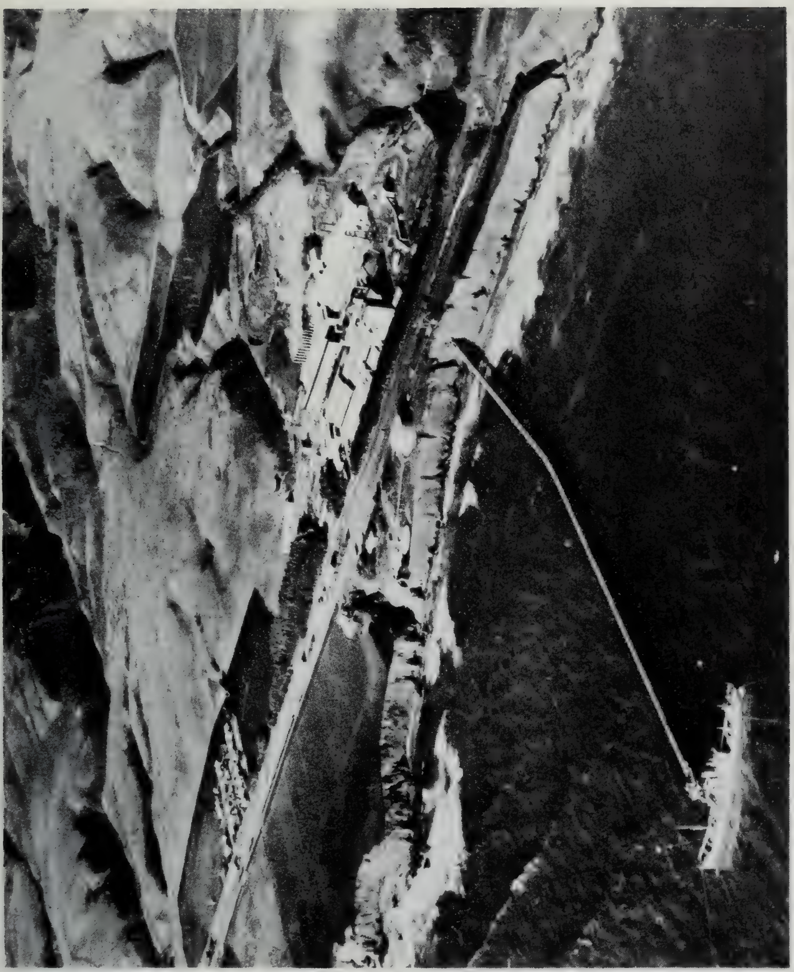

Fig. 7. Plant of Santa Cruz Portland Cement Company, Davenport, California.
Aerial photo by courtesy of the Company.

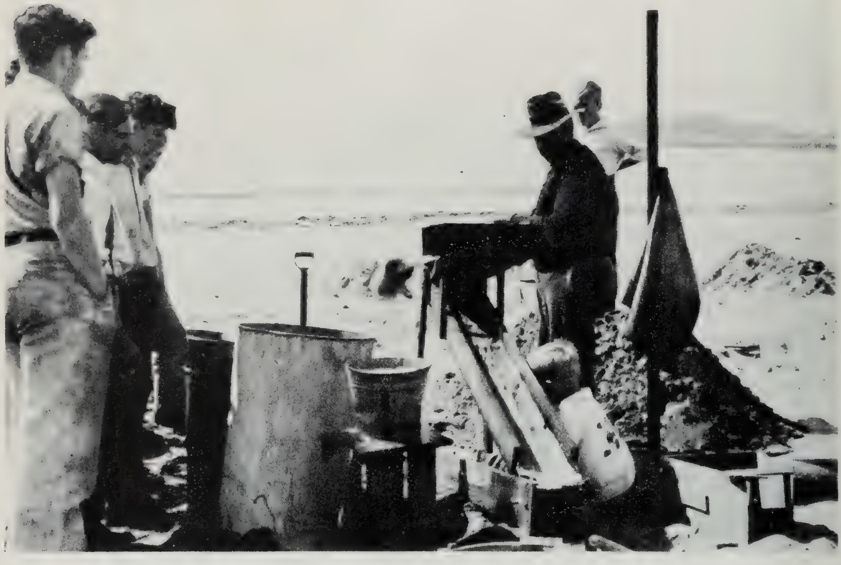

FIG. 8. Washing beach sand for gold, near Twin Lakes, Santa Cruz County, in 1933. Recovery about $1 per day. *Photo by Olaf P. Jenkins.*

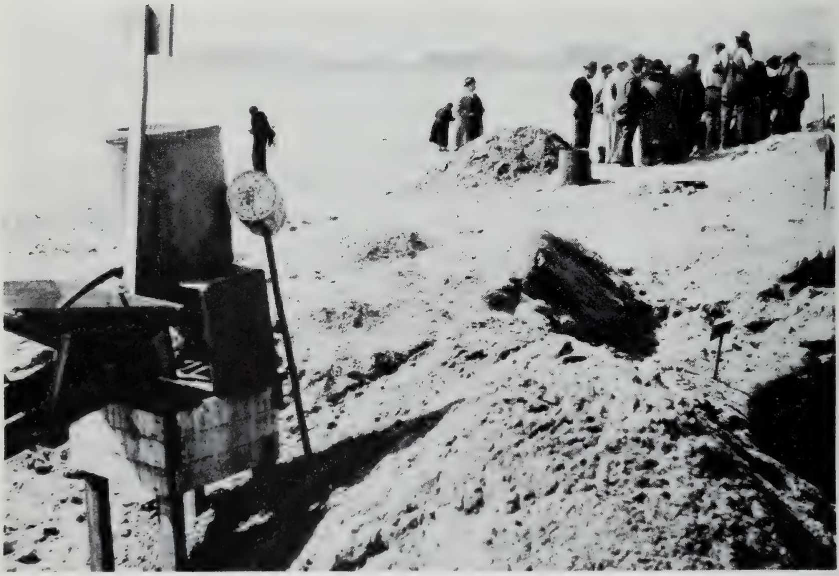

FIG. 9. Washing beach sand for gold, Twin Lakes. *Photo by Olaf P. Jenkins.*

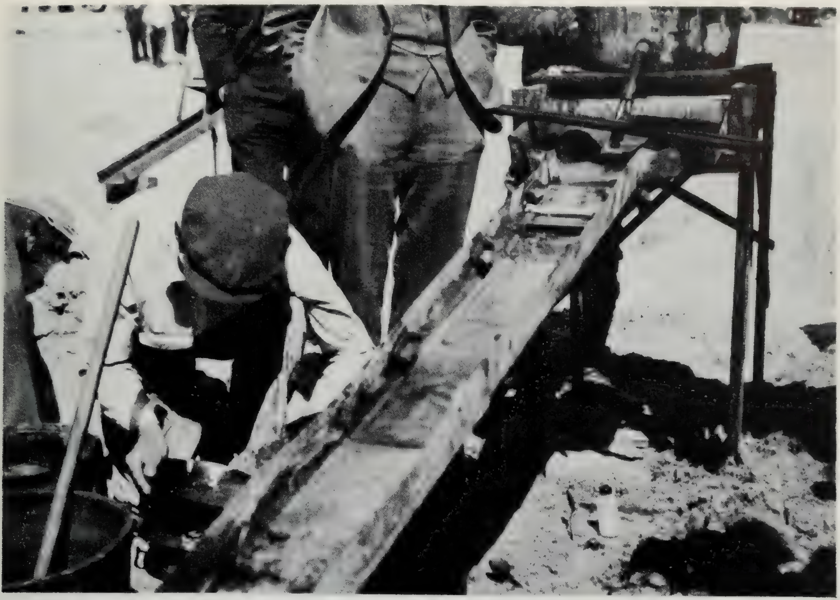

FIG. 10. Washing beach sand for gold, Twin Lakes. *Photo by Olaf P. Jenkins.*

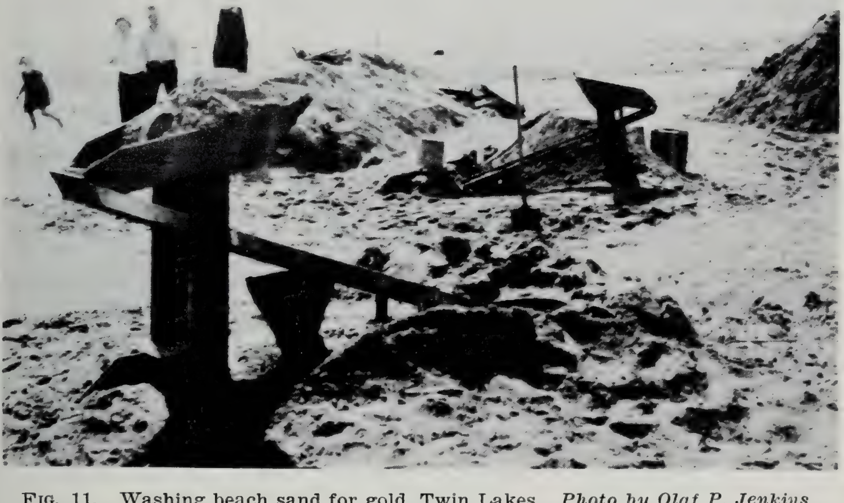

FIG. 11. Washing beach sand for gold, Twin Lakes. *Photo by Olaf P. Jenkins.*

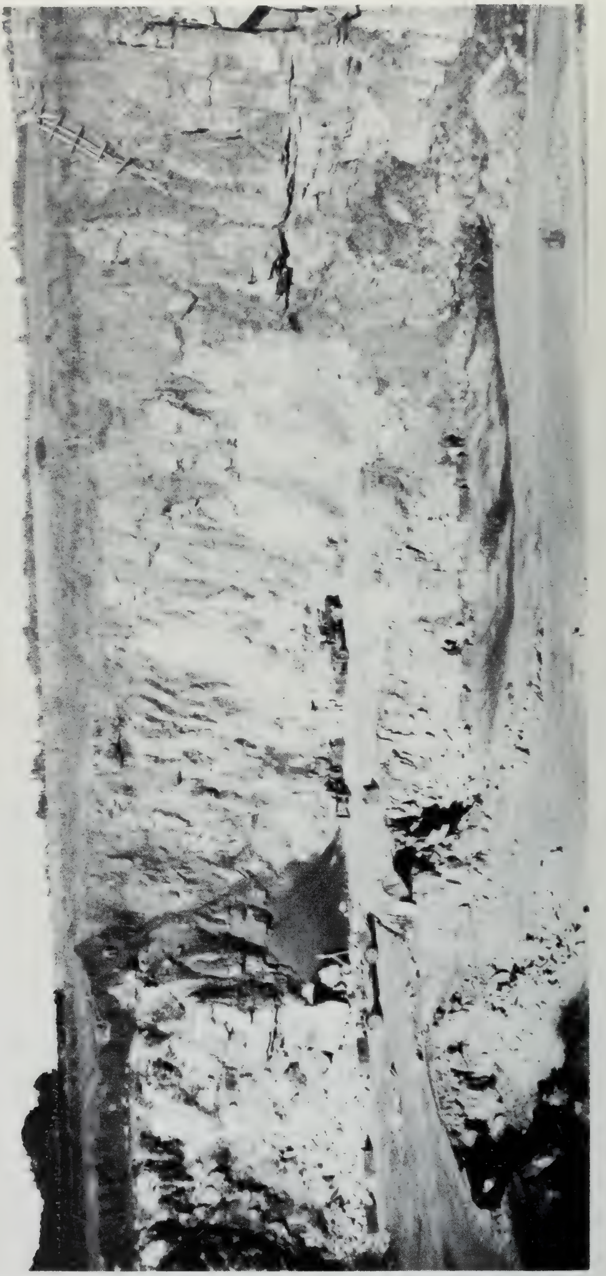

Fig. 12. Pacific Limestone Products Company quarry, Santa Cruz.

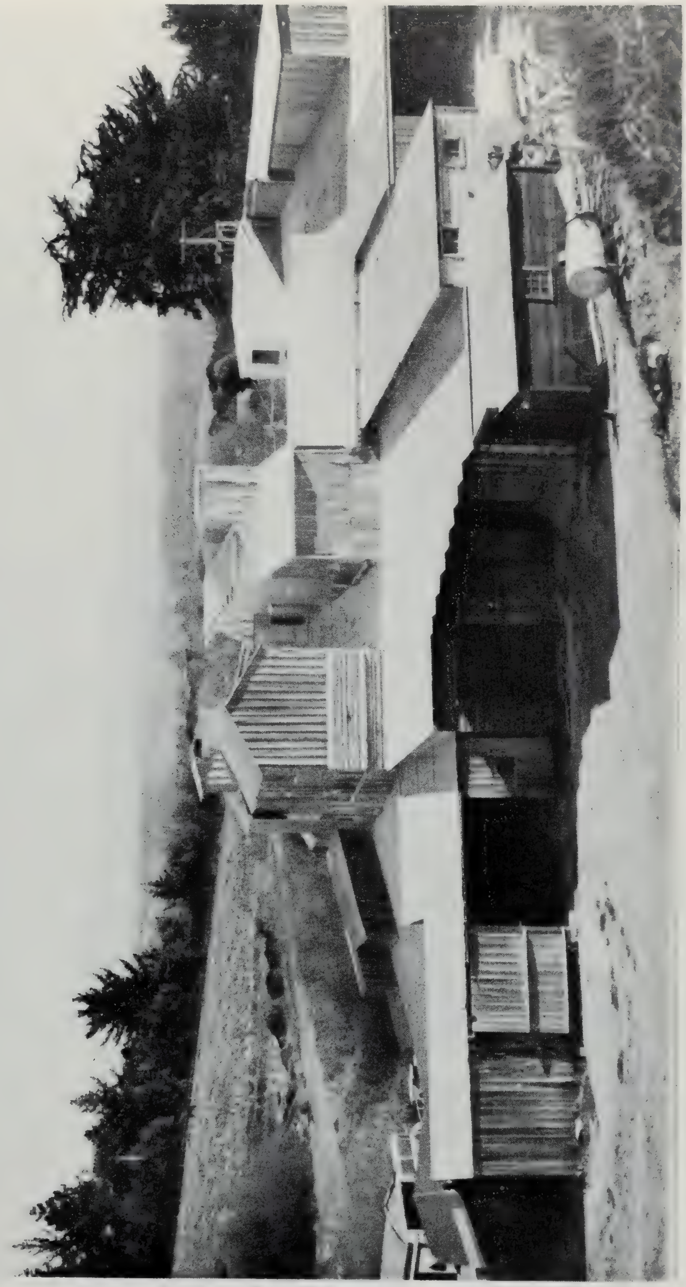

FIG. 13. Pacific Limestone Products Company plant, Santa Cruz.

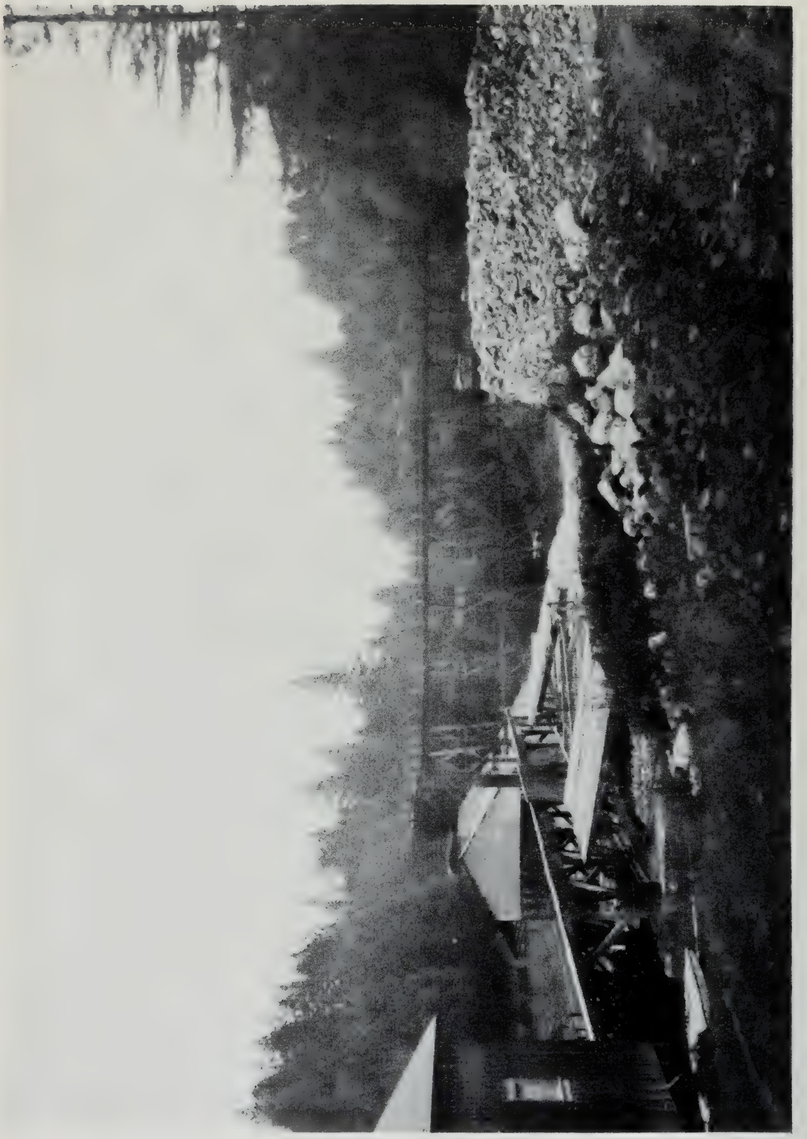

FIG. 14. Henry Cowell Lime and Cement Company's kilns at Rincon.

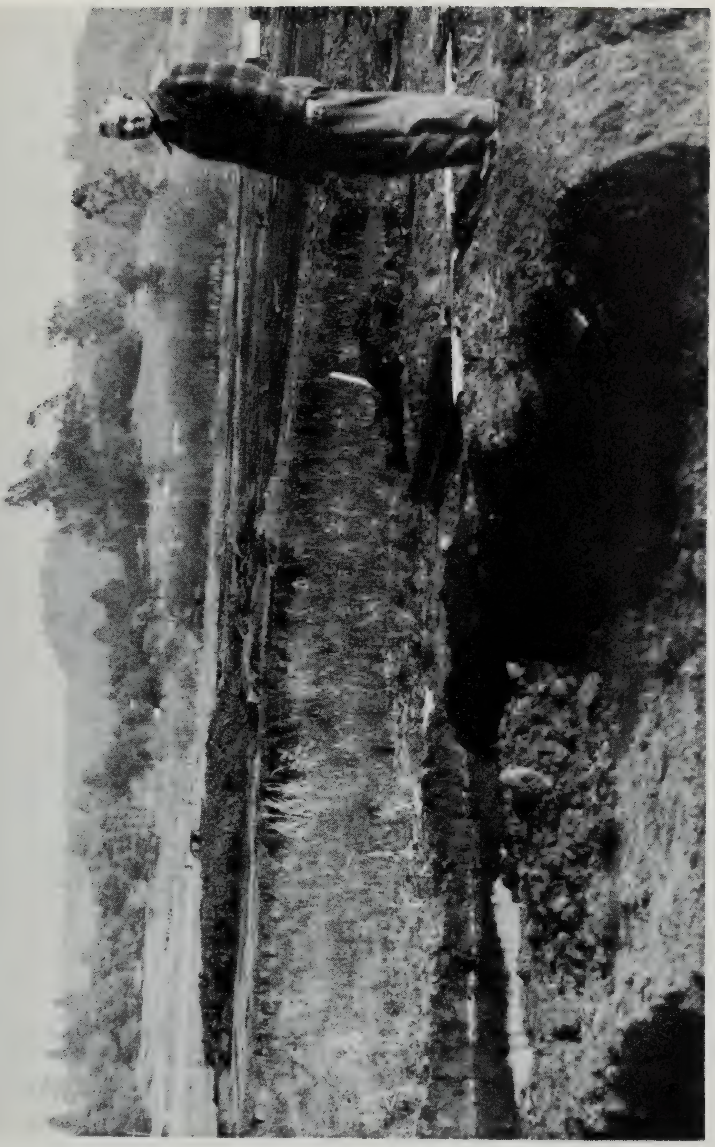

FIG. 15. J. J. Graham peat bog near Felton.

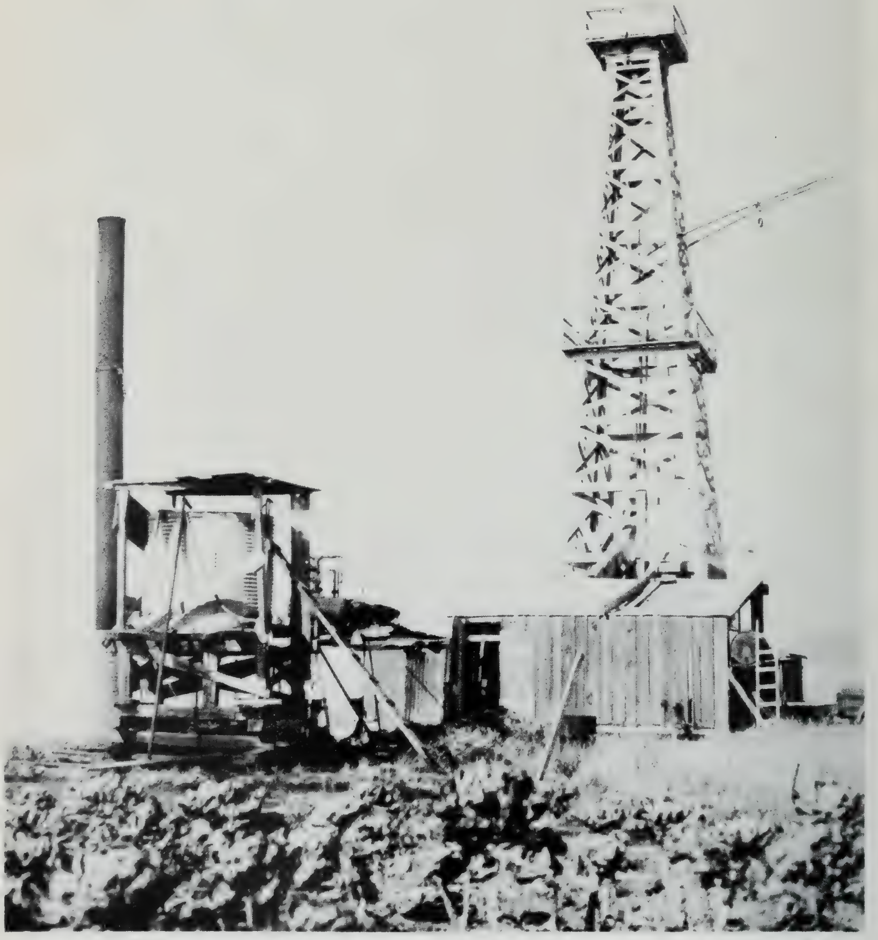

FIG. 16. Monterey Bay Oil Company's "Endurance" well No. 2. This well has been drilling for more than 20 years.

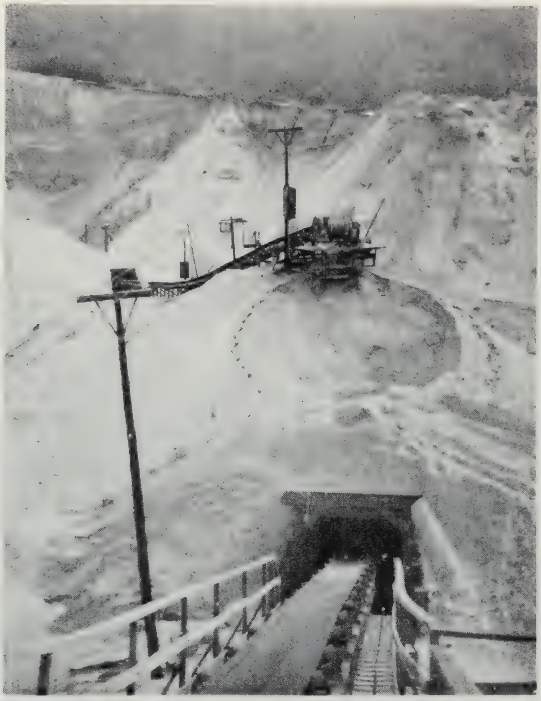

FIG. 17. Olympia sand pit of the Henry J. Kaiser Co., Inc.

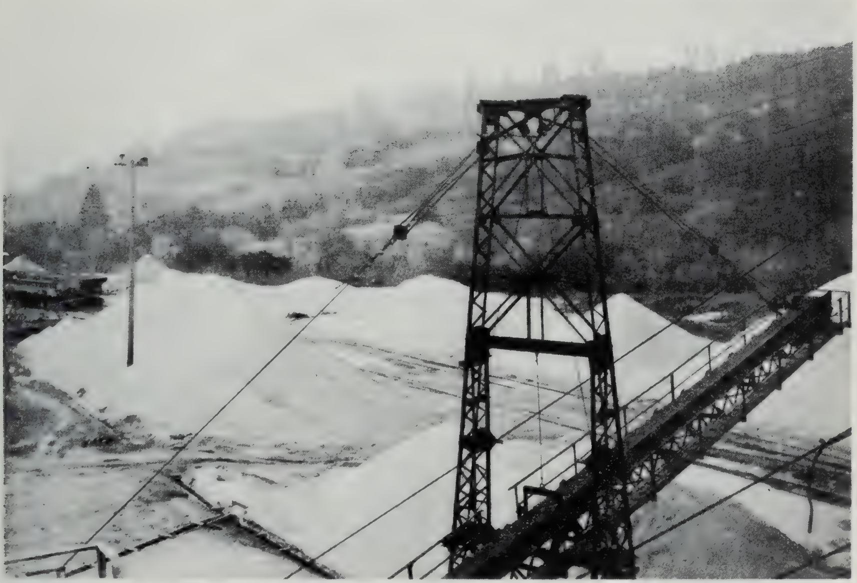

FIG. 18. Henry J. Kaiser Co., Inc., stockpiles.

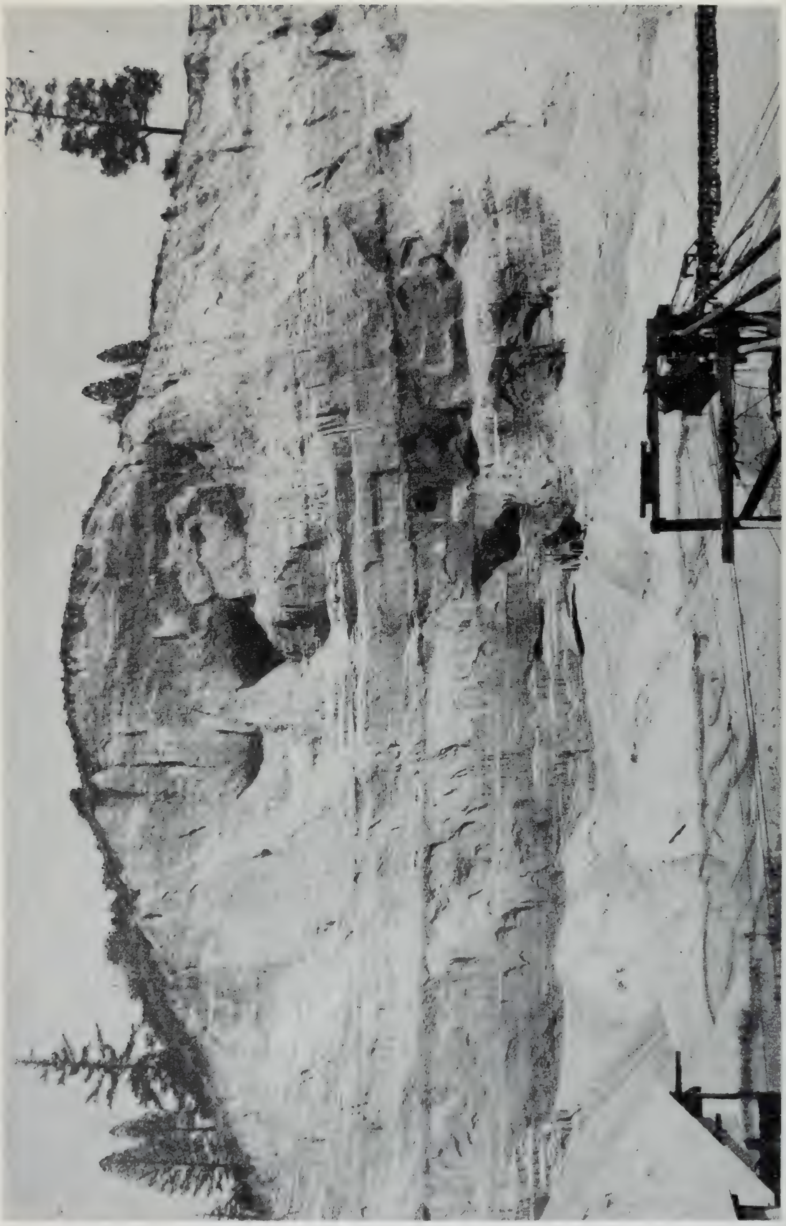

FIG. 19. Before shooting down 100,000 tons of sand at Pacific Coast Aggregates, Inc., Olympia Pit. *Photo by L. H. Chase.*

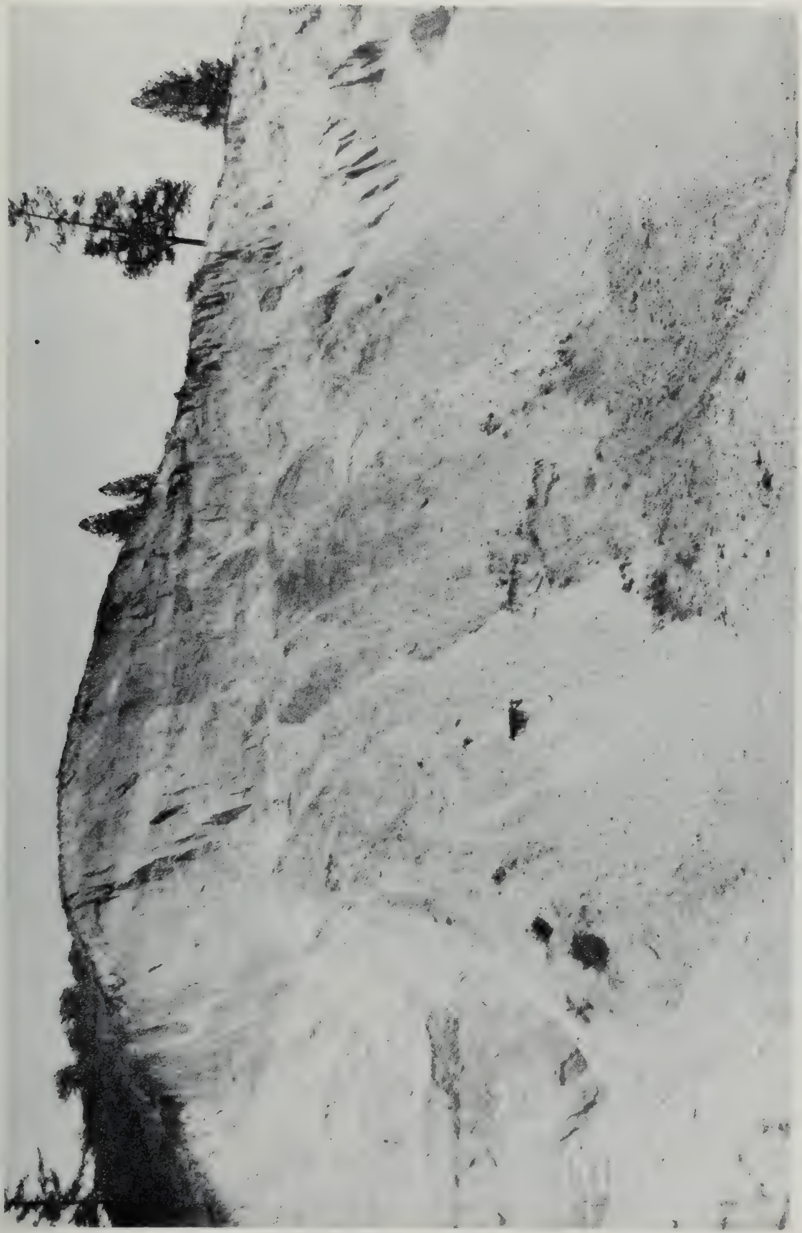

FIG. 20. After shooting down 100,000 tons of sand at Pacific Coast Aggregates, Inc., Olympia Pit. *Photo by L. H. Chase.*

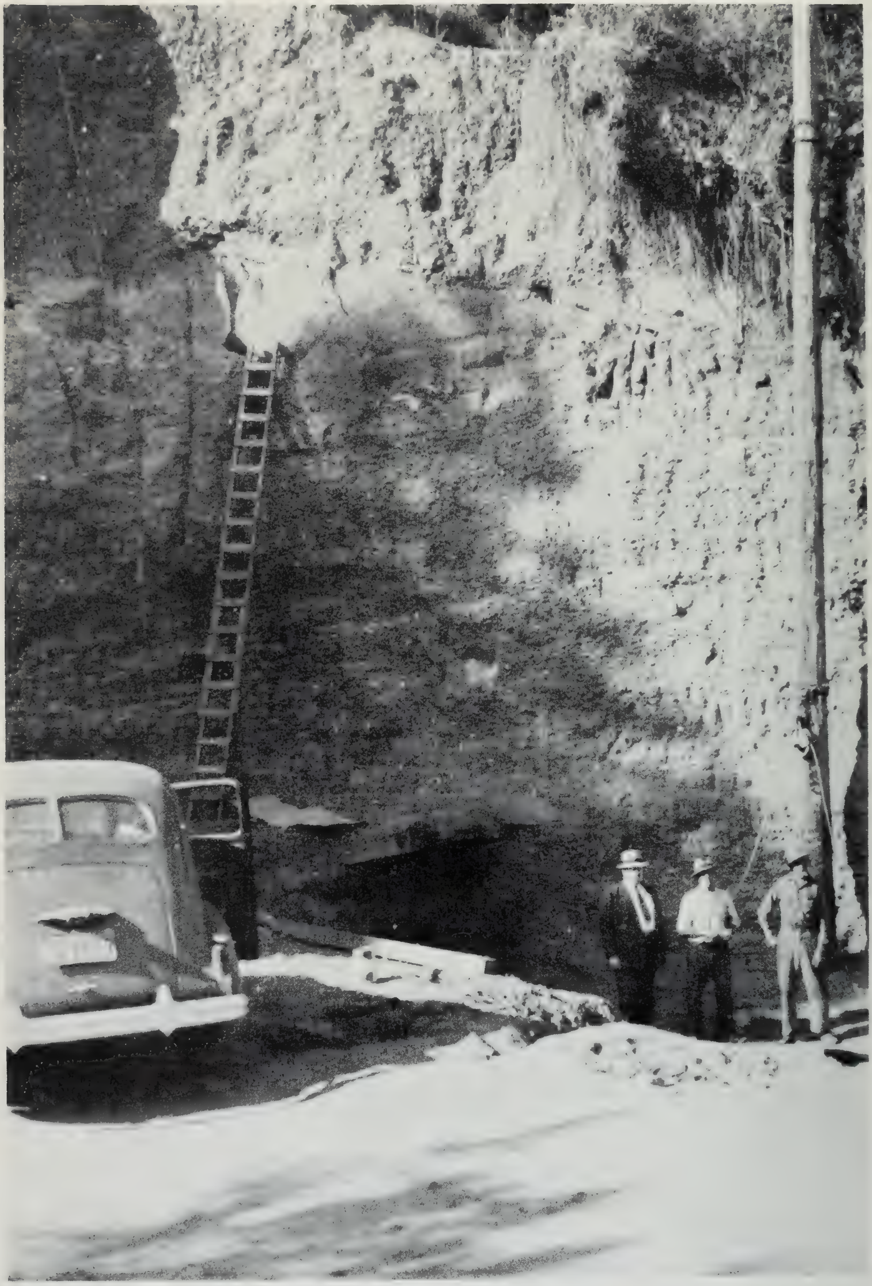

FIG. 21. Titus gravel pit, near Pleasant Valley.

Calrock Asphalt Company. This company was organized in 1929. Maxwell C. Milton, president; Carlton A. Curtis, secretary; J. E. Hayes, manager; T. Landino, plant superintendent. Home office, 525 Market Street, San Francisco; plant at Majors, a station on the Southern Pacific railroad, 8 miles north of Santa Cruz on the coast line (and highway) to Davenport; quarry on the company's private road about 1 mile from the plant, in sec. 12, T. 11 S., R. 3 W., M. D.

This deposit contains approximately 600 acres at an elevation of 500 feet; leased from Thos. E. Majors and J. R. J. Majors. The present face is about 50 feet, after 25 feet of overburden has been stripped off. Material differs in many respects from that formerly mined from the City Streets Improvement Company's mine. It contains 9 percent to 10 percent asphalt and sharp, angular-grained aggregate with uniform-sized grains.

Bituminous rock is shot down by bottom holes in the quarry; hand-sorted and loaded into small steel skips as shown in figure 2. These skips are then dumped into trucks by the drag-line hoist and the material is stock-piled horizontally at the plant. A clam-shell bucket digs the material vertically as needed to feed the plant conveyor-belt and a better blending of the quarry-run is thus obtained. From this conveyor, the material goes to a specially designed roll-jaw primary crusher where it is reduced to four inches and fed to a Williams hammer mill which delivers to screens whose oversize is in closed circuit with the mill. Screened material is of asphalt-sand size and goes to an International dry press to produce asphaltic paving blocks under 20,000 pounds per square inch. Garfield rolls were first used in the plant, but did not give proper service on this material. The quarry run is treated with an asphaltic flux and a mineral filler is added.

Principal product is processed natural rock asphalt for cold paving. The compressed asphaltic paving blocks are second in importance, and cold-laid industrial mastic flooring is also produced. A few of the jobs supplied by this company include part of the Santa Cruz-Los Gatos highway, the Los Angeles Union passenger terminal, and flooring of the Santa Fe Railway freight shed in Emeryville, California.

Production averages about 24,000 tons per year, and the combined crew at plant and quarry comprises 14 or more men.

City Streets Improvement Company's Mine. Under various names, including *Walrath mines, Pacific Improvement Company's mine, Santa Cruz Bituminous Rock mines,* and finally City Streets Improvement Company's mine, this property was operated for more than 36 years, until 1927. Prior to the shutdown, operations had been greatly reduced in scale and the City Streets Improvement Company had gone out of business leaving the property in the hands of its present owner, Bank of California, 400 California Street, San Francisco. Final operations were under a working agreement by I. W. Moore of Santa Cruz.

The property contains 479 acres, located low down on the southern slope of Ben Lomond Mountain at an elevation of 800 to 900 feet. The workings are in sec. 5, T. 11 S., R. 2 W., M. D., 3 miles northeast of Gordola, the shipping point on the Davenport branch of the Southern Pacific, and about 5 miles in an airline northwest of Santa Cruz.

There are three distinct beds of bituminous sandstone lying practically horizontal on the property.

The lower stratum is about 7 feet thick and has not been developed to any extent, as work has been confined to the upper and heavier beds. About 8 feet of sand, containing a very low percentage of bitumen, separates the lower bed from the middle one. The latter is a rather coarse-grained sandstone averaging 30 feet in thickness, containing from 10 percent to 14 percent of asphalt. The soft bituminous rock was mined from this bed. Above it there is a bed of diatomaceous shale 50 to 60 feet in thickness, on top of which is the upper stratum of bituminous sandstone. The upper bed is a little thinner than the middle one, ranging from 6 to 22 feet in thickness. It is finer grained and harder, but contains from 14 percent to 18 percent asphalt. The hard rock was mined from this bed. A varying mixture of the hard and soft rock was used, according to the character of the work to be done.

In early days the material was hauled to the loading station at Gordola by an immense steam tractor, hauling four or five large 10-ton trailers with solid wooden wheels. Much of this old equipment remained on the property as late as 1926.

During 1926 the bituminous sandstone was mined by boring holes with augers, and blasting; the large pieces were broken to man size with sledge and chisel. It was then loaded on 2-ton cars by hand and trammed to a loading bunker from which it was taken by 5-ton trucks to Gordola.

Many thousands of tons of material were produced here in the 36 years of operation; the entire top of Rattlesnake Hill was cut down to the level floor of the middle bed of bituminous sandstone. The beds are still exposed in open cuts for more than 1000 feet on adjoining hills, and an immense tonnage still remains readily accessible. Two to five men were employed immediately prior to the cessation of operations in 1927.

Pavement of this material, under former traffic conditions, and when properly placed, remained in good condition for 30 years. Under modern traffic conditions, however, it would be necessary to treat the material differently, and to supplement it with additional oil.

Bibl.: State Mineralogist's Rept. XII, p. 28; XIII, p. 43; XVII, pp. 230-232; XVIII, p. 228; XXII, pp. 72-74; U. S. Geol. Survey 22nd Ann. Rept., pt. 1, pp. 384-394; Santa Cruz folio 163. California Jour. Technology, August 1913.

Cowell Mine. This quarry is situated in sec. 5, T. 11 S., R. 2 W., M.D., 6 miles northwest of Santa Cruz, on the extensive land holdings of the Henry Cowell Lime and Cement Company. It is about half a mile east of the City Streets Improvement Company's mine, but on the opposite side of Baldwin Creek, which necessitated hauling direct to Santa Cruz for shipment. It had only been worked occasionally in a small way, and was idle in 1926, and has remained idle since.

Bibl.: State Mineralogist's Rept. X, p. 621; XII, p. 28; XIII, p. 44; XVII, p. 230; XVIII, p. 228; XXII, pp. 72-74. U. S. Geol. Survey, 22nd Ann. Rept., pt. 1, pp. 399-404; Santa Cruz folio 163.

Thurber's Mine. This property is north of and adjoining the City Streets Improvement Company's mine. The bed of bituminous sandstone here ranges from 10 to 30 feet in thickness. It has not been extensively developed. Idle. Owner, Bank of California, 400 California Street, San Francisco.

Bibl.: State Mineralogist's Rept. VII, p. 96; VIII, p. 554; XII, p. 29; XIII, p. 44; XVII, p. 232; XVIII, p. 228; XXII, p. 74. U. S. Geol. Survey, 22nd Ann. Rept., pt. 1, pp. 393-396; Santa Cruz folio 163.

Black Sand

There are extensive areas along the coast of California where the heavier constituents of the beach sands have been concentrated by wave action into deposits of black sand. The composition of this heavy concentrate varies somewhat with the locality. In general, the following commercial minerals are present in greater or less amount: magnetite, gold, ilmenite (oxide of iron and titanium), garnet, zircon, hematite, chromite, and the platinum group metals.

Could each of these minerals be readily and completely separated from the others and from the olivine, quartz, and other worthless constituents, they would be readily marketable. Gold and platinum are found in relatively minute amounts only, but practically all past efforts to work the sands have been confined to the recovery of these metals, on account of their high value.

It has been suggested that black sand be used in the manufacture of artificial iron castings, where great strength is not required. Some experimental work has been carried on along this line, including the making of sash-weights by molding or briquetting the material into the desired form with oxy-chloride (magnesite) cement, portland cement, or other binder. Black sand may also be utilized in concrete mixes where a concentrated weight is wanted, as in concrete balance-weights used on bascule-type bridges and similar structures.

By subjecting the magnetite in black sand to an oxidizing roast, it may be changed to the ferric state, producing a red oxide (Fe_2O_3), which, when finely ground, forms a mineral pigment suitable for the manufacture of paint. Pigment so made is said to be superior to ground hematite or the natural soft red oxide.

Magnetite in the black sands is obviously also an ore of iron. Day and Richards[10] in their report on the useful minerals in the black sands of the Pacific slope state:

> "It was found that the magnetite contained in the black sands of the Pacific slope constitutes a greater supply of useful iron ore than any other available source known on the Pacific slope. This magnetite usually contains from 5 to 10 per cent of titanium. It was found that this titanium offered no obstacle to the production of highgrade cast iron in the electric furnace, and that in a modification of this electric furnace this cast iron could even be decarburized to a very soft iron of high quality."

Well-known deposits of black sand occur in Santa Cruz County along many of the beaches, particularly on the northern shore of Monterey Bay from the mouth of Pajaro River to Soquel Point. The deposits are found both on the present beaches and on the older marine terraces back from the present shore line. They occur in strata from a few inches to several feet in thickness, interstratified with light beach sands. They are said to carry small amounts of platinum, as well as gold, and have been washed in the vicinity of Leonard Station and near Aptos at intervals for many years, though probably with little if any profit.

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[10] Day, David T., and Richards, R. H., Useful minerals in the black sands of the Pacific slope: Mineral Resources U. S., 1905, pp. 1175-1258, 1906.

Typical analyses of the natural black sand near Aptos, according to Day and Richards,[11] show their content in the following minerals to be:

Magnetite	502 to 1120 pounds per ton
Chromite	8 to 126 pounds per ton
Ilmenite	224 to 576 pounds per ton
Garnet	1 to 80 pounds per ton
Quartz	216 to 1046 pounds per ton
Zircon	18 to 26 pounds per ton
Unclassified	104 to 189 pounds per ton
Gold	none to 62 cents per ton
Platinum	none

At the time of visit, no one was found attempting to extract gold or platinum, but there is now a plant near Aptos experimenting upon the black sand as an iron ore. For a description of this plant see under Iron.

Carbon-Dioxide Gas

Carbon-dioxide gas has not previously been mentioned in Santa Cruz County reports of this Division other than by a mere note of its presence (percentage not given) in an analysis of the "White Sulphur" spring water at Olive Springs, in State Mineralogist's Report XXII (1926), p. 89.

The writer noted a previously unsuspected CO_2 gas seep in sec. 31, T. 10 S., R. 1 W., M. D., on Branciforte Creek about three miles north of Santa Cruz. The seep occurs in a soil-covered ravine among redwood trees and heavy brush. No rock formations are exposed except in a small open cut for a pathway near the apparent center of the seep. A small fault, striking north, appears in the broken shale beds thus exposed, and it is possible that the seep is located along the fault-fracture of a cap rock in these beds. As in the producing CO_2 gas field of Imperial County, carbonate rocks are prevalent and the San Andreas fault system is nearby. No mineral spring or previous drilling was found but a marked refraction of light rays within a small area on this property is probably caused by the density differential between air containing this gas and the normal atmosphere of the region. Curious visual distortion due to this refraction is being exploited by the owner, George Prather, Route 2, Box 753, Santa Cruz, who has admitted many thousands of paying visitors to his "Mystery Spot" during recent years.

Positive tests with lime-water and with a gasoline-lamp flame were made by the writer, assisted by Philip Morey, a student at the Santa Cruz High School. Prather plans to drill a test well this fall to a depth of 150 or 200 feet in order to determine if CO_2 gas in commercial quality might be encountered at depth.

Cement

Cement is the most important single structural material in the mineral output of California. As a cement producer, the state ranks second in the United States, being surpassed only by Pennsylvania.

California now has 11 operating portland cement mills located in 10 counties.

Of these, the largest single cement mill (and largest in the world) is that of the Permanente Corporation near Los Altos in Santa Clara County. California's second largest such plant is in Santa Cruz County.

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[11] *Op. cit.*, p. 1188.

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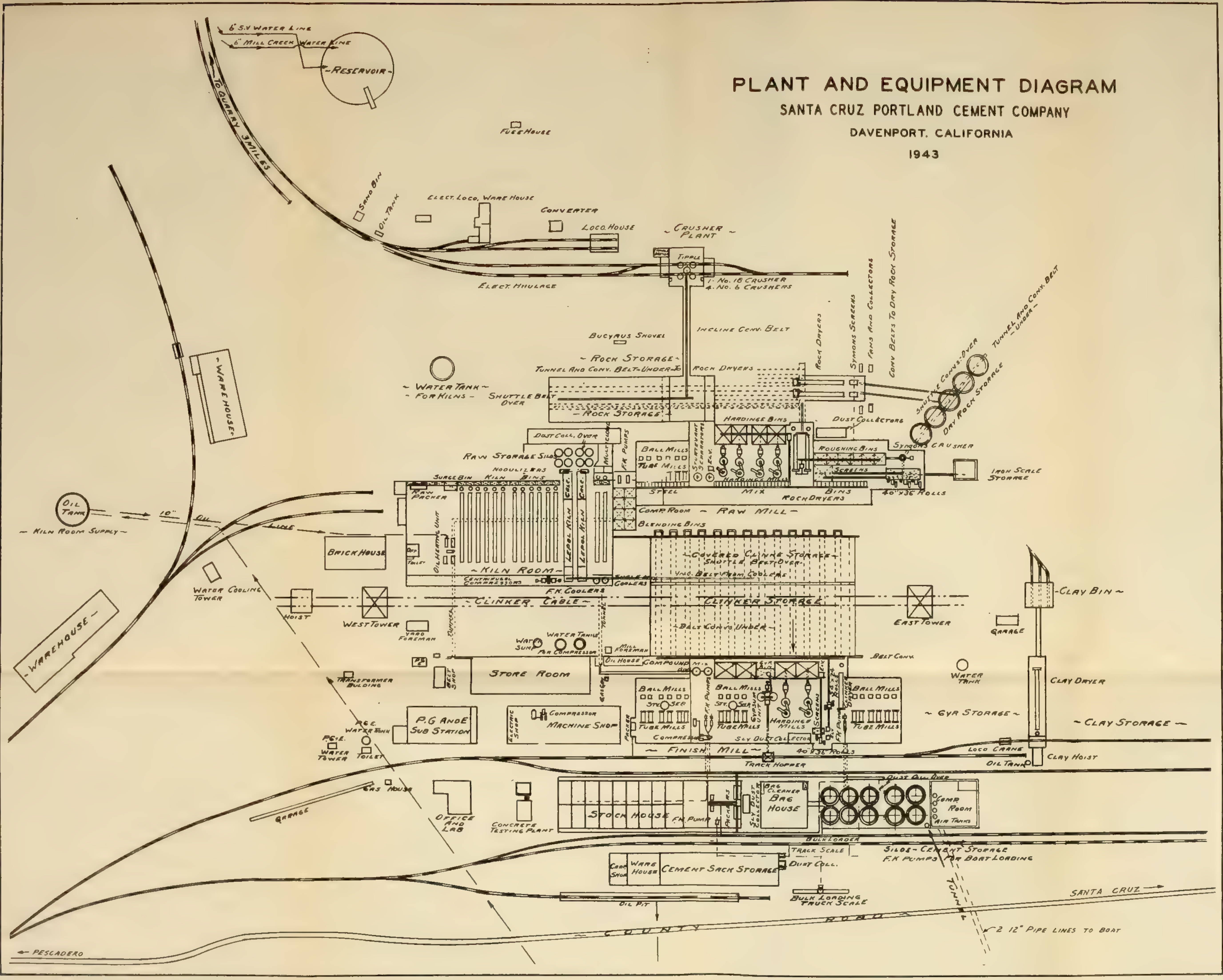
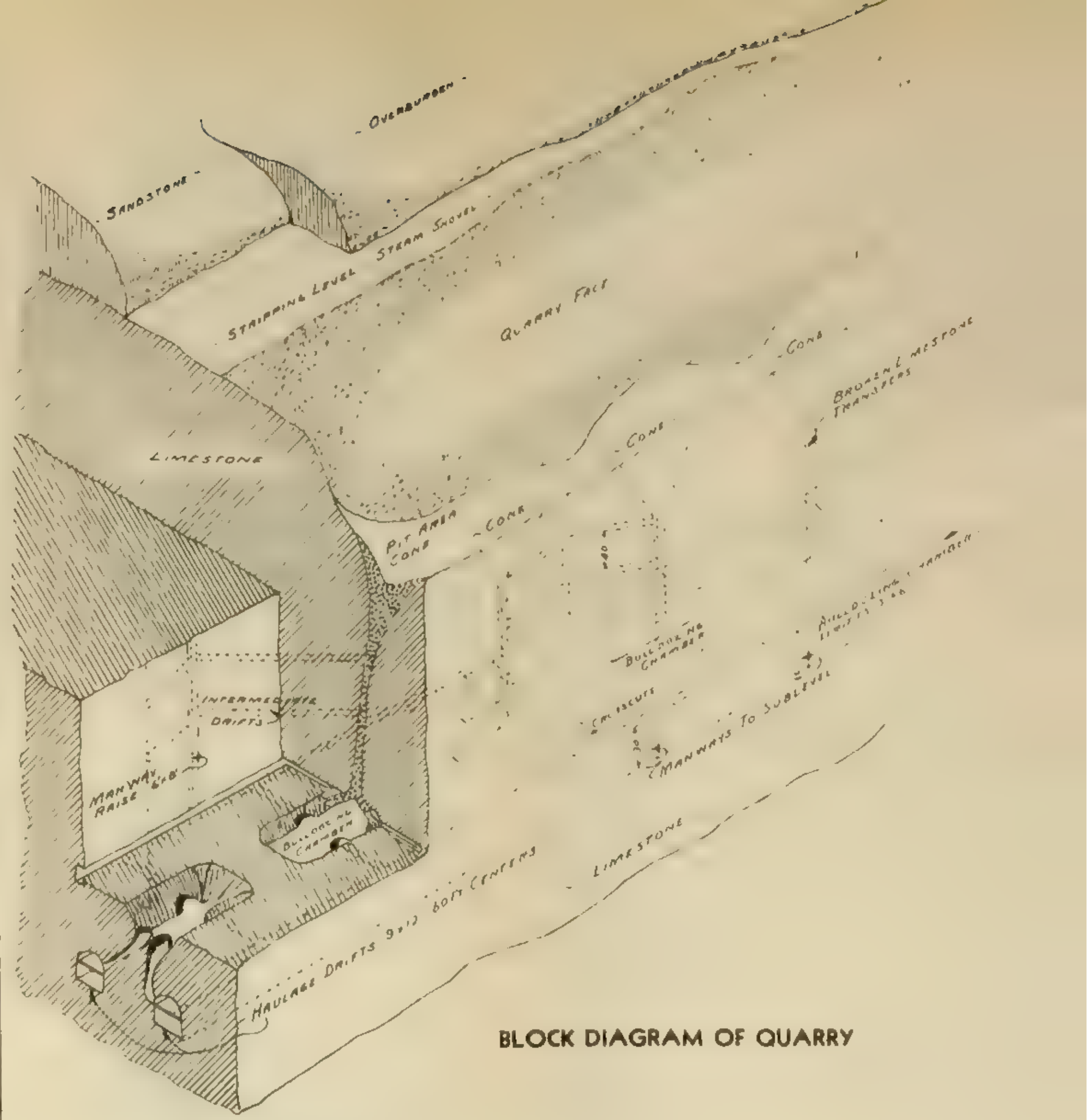


PLANT AND EQUIPMENT DIAGRAM

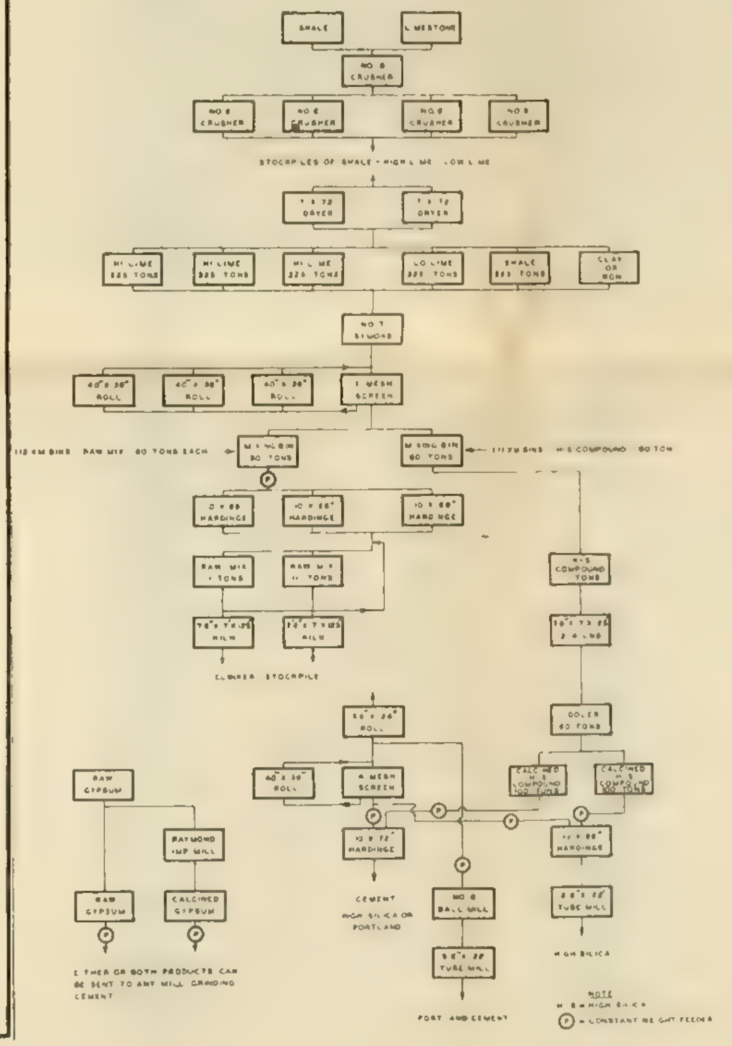
SANTA CRUZ PORTLAND CEMENT COMPANY
DAVENPORT, CALIFORNIA
1943

6" S.V. WATER LINE
6" MILL CREEK WATER LINE
RESERVOIR
TO QUARRY 3 MILES
FUSE HOUSE
SAND BIN
OIL TANK
ELECT. LOCO. WARE HOUSE
CONVERTER
LOCO. HOUSE
CRUSHER PLANT
TIPPLE
1 - No. 18 CRUSHER
4 - No. 6 CRUSHERS
ELECT. HAULAGE
BUCYRUS SHOVEL
INCLINE CONV. BELT
ROCK STORAGE
TUNNEL AND CONV. BELT - UNDER
ROCK DRYERS
WATER TANK FOR KILNS
SHUTTLE BELT OVER
ROCK DRYERS
SYMONS SCREENS
FANS AND COLLECTORS
CONV. BELTS TO DRY ROCK STORAGE
TUNNEL AND CONV. BELT UNDER
SHUTTLE CONV. OVER
DRY ROCK STORAGE
HARDINGE BINS
DUST COLLECTORS
SYMONS CRUSHER
ROUGHING BINS
SCREENS
IRON SCALE STORAGE
DUST COLL. OVER
RAW STORAGE SILOS
BALL MILLS
TUBE MILLS
STURTEVANT SEPARATORS
F.K. PUMPS
NODULIZERS
SURGE BIN
KILN BINS
RAW PACKER
STEEL
MIX
BINS
ROCK DRYERS
40" x 36" ROLLS
COMP. ROOM
RAW MILL
BLENDING BINS
OIL TANK
10" OIL LINE
KILN ROOM SUPPLY
BRICK HOUSE
OIL HEATING UNIT
LEPOL KILN
LEPOL KILN
KILN ROOM
CENTRIFUGAL COMPRESSORS
COVERED CLINKER STORAGE
SHUTTLE BELT OVER
INC. BELT FROM COOLERS
COOLERS
F.K. COOLERS
WATER COOLING TOWER
HOIST
WEST TOWER
CLINKER CABLE
CLINKER STORAGE
EAST TOWER
CLAY BIN
GARAGE
BELT CONV. UNDER
YARD FOREMAN
WATER SUMP
WATER TANKS FOR COMPRESSOR
MILL FOREMAN
WAREHOUSE
WAREHOUSE
STORE ROOM
OIL HOUSE
COMPOUND
BELT CONV.
WATER TANK
CLAY DRYER
TRANSFORMER BUILDING
P.G. AND E. SUB STATION
ELECTRIC SHOP
COMPRESSOR
MACHINE SHOP
PACKER
BALL MILLS
STURT. SEP.
TUBE MILLS
COMPRESSOR
HARDINGE MILLS
SLY DUST COLLECTOR
GYP. STORAGE
CLAY STORAGE
P.G. & E. WATER TANK
P.G. & E. WATER TOWER
TOILET
FINISH MILL
40" x 36" ROLLS
LOCO. CRANE
CLAY HOIST
OIL TANK
TRACK HOPPER
DUST COLL. OVER
GAS HOUSE
GARAGE
OFFICE AND LAB
CONCRETE TESTING PLANT
STOCK HOUSE
F.K. PUMP
SLY DUST COLL.
BAG CLEANER
BAG HOUSE
COMP. ROOM
AIR TANKS
BULK LOADER
SILOS - CEMENT STORAGE
F.K. PUMPS FOR BOAT LOADING
TRACK SCALE
CORP. SHOP
WARE HOUSE
CEMENT SACK STORAGE
DUST COLL.
BULK LOADING TRUCK SCALE
OIL PIT
TUNNEL
SANTA CRUZ
COUNTY ROAD
PESCADERO
2 12" PIPE LINES TO BOAT



BLOCK DIAGRAM OF QUARRY

SANDSTONE
OVERBURDEN
STRIPPING LEVEL
STEAM SHOVEL
QUARRY FACE
LIMESTONE
CONE
CONE
CONE
PIT AREA CONE
BROKEN LIMESTONE TRANSFERS
INTERMEDIATE DRIFTS
MANWAY RAISE
MANWAYS TO SUBLEVELS
LIMESTONE
HAULAGE DRIFTS 9x15 80ft CENTERS



FLOW SHEET
SANTA CRUZ PORTLAND CEMENT CO.
JANUARY 943

SHALE
LIMESTONE
NO. 8 CRUSHER
NO. 6 CRUSHER
NO. 6 CRUSHER
NO. 6 CRUSHER
NO. 6 CRUSHER
STOCKPILES OF SHALE - HIGH LIME - LOW LIME
DRYER
DRYER
HI LIME
HI LIME
HI LIME
LO LIME
SHALE
CLAY OR IRON
NO. 7 SYMONS
40" x 36" ROLL
40" x 36" ROLL
40" x 36" ROLL
MESH SCREEN
RAW MIX 80 TONS EACH
MIXING BIN 80 TONS
MIXING BIN 80 TONS
COMPOUND 80 TON
HARDINGE
HARDINGE
HARDINGE
RAW MIX TONS
RAW MIX TONS
KILN
KILN
CLINKER STOCKPILE
COMPOUND TONS
KILN
COOLER 40 TONS
ROLL
40" x 36" ROLL
MESH SCREEN
CALCINED COMPOUND 100 TONS
CALCINED COMPOUND 100 TONS
HARDINGE
HARDINGE
RAW GYPSUM
RAYMOND IMP MILL
RAW GYPSUM
CALCINED GYPSUM
CEMENT HIGH SILICA OR PORTLAND
NO. 8 BALL MILL
TUBE MILL
TUBE MILL
HIGH SILICA
PORTLAND CEMENT
EITHER OR BOTH PRODUCTS CAN BE SENT TO ANY MILL GRINDING CEMENT
NOTE
P = CONSTANT WEIGHT FEEDER

By courtesy of Santa Cruz Portland Cement Co.

Santa Cruz Portland Cement Company. Home office, Crocker Building, San Francisco; plant at Davenport, Santa Cruz County; officers, George T. Cameron, president; D. J. Murphy, secretary; George R. Gay, manager; Robert A. Kinzie, Jr., plant superintendent; L. R. Davis, quarry superintendent.

This company's mill site is at Davenport near the northern terminus of the marine terrace which borders the ocean northwestward from Santa Cruz for 15 miles. The plant is within sound of the surf about half a mile north of San Vicente Creek Canyon and 11 miles from Santa Cruz. A branch line of the Southern Pacific Railroad from Santa Cruz serves it. A good paved highway, coast route to San Francisco, closely parallels the railroad. An important improvement added by this company in 1935 was the steamship ''Santacruzcement'' and its loading pier. (See fig. 7.) As a supplement to rail shipments, the steamer has satisfactorily met the owners' expectations during its 8 years of service. It is the only ocean-going bulk-carrier of cement. It is 414 feet long, has a beam of 54 feet, and a 25-foot draft when loaded. The boilers carry steam at 200 pounds pressure, and the triple expansion engine is rated at 3,000 indicated horsepower. The capacity of the ship is 45,000 barrels of cement. It has a speed of 10 knots when loaded, and is equipped with a complete dust-collecting system.

The first shipment of cement from this plant was made on May 17, 1907, since which time the company has been in continuous production, although not always at full capacity. The mill at present has a capacity of 10,000 barrels per day (subject to variation with the several types of cement produced),[12] and about 335 men are on the payroll. Electric power furnished by the Pacific Gas and Electric Company is used throughout, the connected load being approximately 12,000 horsepower.

The limestone and the clay used at the plant are obtained from the company quarry located in sec. 15, T. 10 S., R. 3 W., M. D., 3 miles up San Vicente Canyon. Except for small amounts of southern California gypsum substituted in emergencies, the gypsum used comes from Nevada.

Additions to and changes in equipment and methods of operation, both at the mill and at the quarry, have been adopted from time to time and some radical changes (including two new dryers) in the mill flowsheet are now under way.

The accompanying equipment diagram (plate 1) corrected to January 4, 1943, is not a complete plan of the mill, but is intended to give only a general idea of the layout. It does not indicate the conveyor distributing system with its automatic weighing and mixture-control arrangement and many other details. A low-pressure oil-burning system has replaced the high-pressure system used many years ago. Hummer-screens, rolls, and Hardinge mills have been added, in part replacing tube and ball mills.

The most important change at the quarry in its history has been the abandonment of the original open quarry, worked for many years prior to 1926 by a single bench with steam-shovel loading, and the substitution of a different method of quarrying, designed and put in operation by Robert A. Kinzie, Sr., mining engineer, of San Francisco. An isometric sketch of quarry method is shown on plate 1.

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[12] *See also* Kinzie, Robert A. Jr., Production of high-silica cement by Santa Cruz Portland Cement Company; Am. Inst. Min. Met. Eng. Contr. 67, 10 pp., February 1934.

The quarry and method of working were described in great detail in two illustrated articles by George J. Young,[13] of which the following (with some revisions and corrections to date) is a brief resume.

Operations are divided into stripping and quarrying. Stripping is done under contract by diesel shovel and trucks, by caterpillar bulldozers, and in the case of soft soil, by Le Tourneau carryalls. Stripping is carried on sufficiently in advance to meet seasonal and other varying conditions. This contractor employs a crew of about 20 men.

The quarry working plan is a combination of glory holes, transfer raises, bulldozing chambers, chute loading and adit transportation. Since it was put into operation (prior to 1925), over 8,000,000 tons of limestone have been delivered to the mill at a greatly reduced cost.

On the quarry loading-out level three haulage drifts 9 by 12 feet on 60-foot centers extend along the principal axis of the deposit. Between these drifts at an elevation of 30 feet above the haulage level are a series of bulldozing chambers. Each chamber is 60 feet in length, and 25 to 30 feet in width, its bottom being hoppered out and connected to two chute raises located on the same side, thus providing continuous production even if one chute should hang up. The chute raises, 6 by 8 feet in section, are driven at an angle of 50 degrees with the bottom angle reduced to 37 degrees and are fitted with underswung arc-gates. These gates were converted in 1927 from manual to pneumatic actuation by installing two 5 by 26-inch cylinders on each gate. Great ease and safety in operation results, since the loader stands well aside from the flow of rock and merely turns a four-way valve as desired. More than 33 chutes are now available for loading. The haulage cars have steel bodies of 253 cubic feet capacity and are loaded to 13 tons. Three storage-battery locomotives are used for handling the cars in the drifts. They are handled in 8- to 10-car trains, both locomotives and cars being equipped with air brakes. The cars are made up in 200-ton trains in the quarry yard and 10 trains per day are dispatched to the mill. Two 18-ton trolley-type electric locomotives are used for this work. Cars are dumped at the plant by an electrically operated revolving tipple.

From the top of each bulldozing chamber, a raise 10 by 11 feet square extends to the floor of the quarry. These raises establish the position of the surface glory holes. They are spaced as much as 240 feet apart as character of rock and other conditions dictate. Six raises have so far been extended to the quarry level. A glory hole is started by coning out the top of the raise to an angle of approximately 60 degrees. During the coning out the broken rock in the raises is drawn down to expose the benches that are cut. Bulldozing is done with 40 percent Extra powder in the bulldozing chamber whenever necessary through man-way raises, intermediate and sub-drifts (the latter two being spaced 40 feet apart). Much labor economy, elimination of hang-ups, and greatly improved safety have been attained at slightly increased explosives cost by the use of 60 percent gelatin cartridges and one stick of 60 percent nitro-glycerine for the primer. An explosive wave of 18,000 feet per second is thus obtained as compared with the 5,000- or 6,000-foot wave resulting from use of ordinary 60 percent dynamite. Another important factor in this desirable increase in the blast-fragmentation has been the spacing of drill holes at 6 feet apart and at 6 or 7 feet back from the face instead of 10 to 12 feet apart (and back) as was done in years past. Detachable drill bits are used. Few serious hang-ups in the system have occurred even though one raise is drawing from a portion of the quarry that contains a good deal of clay mixed with the limestone.

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[13] Young, George J., Mining limestone by glory holes in California: Eng. and Min. Jour. vol. 120, pp. 249-253, 1925; *and* Eng. and Min. Jour., vol. 127, pp. 954-956, 1929.

A total of 43 men are employed at the quarry, in addition to the contractor's 20-man stripping crew, for the present average output of 2000 tons per day, which is equivalent to 32 tons output per man-shift. Development costs have steadily decreased to the present figure of about 2 cents per ton.

The deposit extends over a width of 1200 feet for approximately three-quarters of a mile. It is an homogeneous close-grained light-gray to white limestone free from magnesium carbonate. The area was diamond-drilled prior to the adoption of the glory-hole method and its extent found to be greater than anticipated, the tonnage being sufficient for a long period of operation.

Bibl.: State Mineralogist's Rept. XXII, pp. 75-78.

Clay

Up to the present time the clay deposits in Santa Cruz County have been only superficially studied. Common clays, suitable for brick-making and similar uses, are known to occur along San Lorenzo River and at other points, and there is no doubt a plentiful supply of such low-grade clays. In the early nineties two brickyards were in operation near Santa Cruz, but these have long since been dismantled.

A deposit of pottery clay on the property of J. B. King, Skyland (P. O. Wrights Station), was reported to the State Mineralogist in 1926 but no sample was submitted then, nor was the owner available during the present field work.

On the Neary Ranch clay deposit, borings were made to a depth of 50 feet some years ago, but definite information on this deep test is lacking. More recently the owner, Miss Alice Neary, 77 Mission Street, Santa Cruz, submitted a sample taken from a 5-foot bore-hole to the Division of Mines laboratory for identification. This sample was reported to her as being of possible commercial value for porcelain or pottery and she plans to contact various potteries that may be interested. The deposit comprises about 40 level acres of the marsh-land adjoining on the west the Santa Cruz depot grounds of the Southern Pacific railroad. It is in sec. 13, T. 11 S., R. 2 W., M. D.

The only clay now produced in the county is that used by Santa Cruz Portland Cement Company. It is mined at their own limestone quarry, and used in the manufacture of cement at the company's plant at Davenport.

Bibl.: State Mineralogist's Rept. X, p. 625; XII, p. 383; XIII, p. 619; XVII, p. 234; XXII, pp. 78-79; Preliminary Rept. 7, p. 97; Bull. 99, p. 222.

Coal

Several small beds of lignite have been found in Santa Cruz County. Prospecting for coal north of Watsonville was active during the early eighties and a little coal was mined on Corralitos Creek about that time. During the years 1925 and 1926 one of these beds in the vicinity of Corralitos was reopened and the coal sold for domestic purposes in Santa Cruz.

As much of the coal in California is lignite, or of such low grade that it cannot be used to advantage as a steam coal, investigations have been under way to determine an economical method of utilizing the deposits, particularly in the direct production of sponge iron and steel in the electric furnace. The low-temperature distillation process with the production of a semi-coke briquette (said to be an ideal smokeless domestic fuel) and various by-products, has also been investigated. Experiments which give promise of success have been made to purify lignites and low-grade coals by some process such as the Trent method, which consists of agitating together powdered coal, water, and oil. This produces a partly de-ashed plastic fuel called ''amalgam,'' the oil selecting the coal particles and largely excluding the water and ash. In one experiment on a California lignite, the ash reduction amounted to 26.8 percent, the combustible recovery was 95 percent, and the sulphur reduction was 12 percent after treatment. The manufacture of calcium carbide (CaC_3) from lime and lignite coal has also been considered. Still other investigations have undertaken to show how the coals may be utilized in powdered form, either alone or with oil in ''colloidal'' fuels; to make them into briquettes without the use of an expensive binder; to manufacture producers gas from them; and to obtain for commercial use their other constituents, including ammonia, benzol, toluol, solvents, drugs, oils, and other coal products.

One of the later developments is a process for extracting oil from coal, in which powdered coal held in oil is subjected to high temperature and agitation in an atmosphere of hydrogen. Under these conditions it is reported that 10 to 45 percent of the coal will become soluble. After removal of the carrying oil there remains a pitch or asphalt-like product possibly capable of further hydrogenation.

These various possibilities lend additional interest to the development of any coal beds within the county, in addition to the ordinary use of the coal for domestic fuel.

Look Coal Mine. This property comprises 10 acres situated on Redwood Canyon in sec. 30, T. 10 S., R. 2 E., M. D. Owner, George Burman, Route 5, Watsonville (residence, Corralitos). There is a good road to the mine from Corralitos, the nearest town. It is approximately 9 miles from the mine either to Watsonville or to Aptos, the nearest railroad points, and 19 miles to Santa Cruz. Elevation at the mine is 800 feet. The surface rises steeply from Redwood Creek toward the west, and is thickly covered with redwood, tanbark oak, and brush.

The existence of a bed of coal on this property and croppings on adjacent tracts have been known for many years, but were considered of little importance. The showing here was the most prominent, and the former owner, C. R. Look of Santa Cruz, acquired the land about 10 years prior to starting work on the coal vein in 1924. Development was continued in 1925, the old adits being cleaned out and extended. A raise was put up on the bed from the lower to the upper adit in 1926. The 75 to 90 tons of coal removed was sold in Santa Cruz and vicinity. One man was employed at that time.

The bed appears to strike east and dip 45° S., but is exposed only near the creek level where the canyon cuts across it. Both adits are driven in on the bed and run almost due west. The lower one is in 200 feet and the upper one, about 20 feet higher and 20 feet northerly, is in 100 feet. Both portals are now partially caved and water has backed up into the lower adit. The roof and floor are both sandstone. The bed is fairly regular but ranges in width from 3 to 4 feet. The coal is a fair grade of lignite, black in color, but showing some laminations, and inclined to slack on exposure, though this slacking is not pronounced if the coal be protected from the weather. It has not proved to be a satisfactory fuel in an open fireplace, but Laizure[14] states that he saw it burning freely with no soot in an ordinary kitchen range, giving a bright hot fire. The ash is fine, reddish-gray in color, but may amount to as much as 20 percent. No analyses have been made. The former owner stated that where the coal has been burned in a stove with a grate and good draft, users report it very satisfactory.

There are indications of some parallel beds nearby, but no work has been done on them. On another ranch, about a quarter of a mile east of the Look workings and approximately on the strike of this bed, there is another exposure in a road cut. This may be an extension of the Look bed, but at the more easterly showing the dip is exactly opposite, being about 45° N. Possibly this is only a localized fold or breakover. No work has been done here.

Leonard Ranch Coal Deposit. A bed of lignite from 6 to 18 inches in thickness, lying approximately horizontally between sandstone walls, is exposed in the bluffs facing the ocean beach on the P. M. Leonard Ranch, 2 miles southeast of Aptos, in T. 11 S., R. 1 E., M. D. The property was last reported under lease as a ranch to Bontadelli and Son. In a small creek some distance back from the beach a hole about 6 feet deep showed 18 inches of the coal. It is black in color but laminated and friable, due no doubt in part to long exposure. No fresh material was in sight. The bed is thicker here than on the beach, indicating that still farther inland a workable bed might be developed.

Gold

Gold occurs in Santa Cruz County in black sand deposits, as placer deposits in a number of creeks and gulches on the sides of Ben Lomond Mountain, and in small quartz seams on Ben Lomond Mountain. During the eighties there was considerable activity both in working the black sand deposits near San Andreas and the placers and veins in the vicinity of Felton. The principal placers were on Waddell Creek, Major Creek, and Gold Gulch. Colors of gold are not difficult to obtain in the gravels along Gold Gulch, and some placer mining was done here as late as 1920. Again, during the 1932 depression, large numbers of placer miners were active on many of the black sand beaches along Monterey Bay. Some few of these operators, with simple equipment (see figs. 8 to 11), were able to recover as much as a dollar's worth of gold per day; but the majority made far less. Former operations are described in early reports of the State Mineralogist, and by E. S. Harrison.[15]

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[14] Laizure, C. McK., Santa Cruz County: California Min. Bur. Rept., vol. 22, no. 1, pp. 79-82, January 1926.

[15] Harrison, E. S., History of Santa Cruz County, California: pp. 203-204, Pacific Press Publishing Co., San Francisco, 1892.

The industry, if such it could ever have been called, gradually diminished, and it is now a matter of history, about the only reminders being the token production (such as the 19 fine ounces recorded for 1940) and the name Gold Gulch, near Felton on the map. The larger land holdings in this vicinity have been subdivided for summer homesites and residence purposes and it is doubtful if any tracts would be sold or leased for mining purposes.

The black sand deposit near Aptos (where some experimentation by Coast Metals and Reduction Company is still in progress upon the magnetite, ilmenite and chromite) was stated by the former operator, Triumph Steel Company, to carry about 20 cents per ton in gold, but no effort has been made to recover it in recent years. See under Iron and Black sand.

Bibl.: State Mineralogist's Rept. VIII, pp. 550-553; X, pp. 622-624; XII, pp. 243-244; XVII, pp. 235-236; XXII, p. 82.

Granite

Granite has been quarried from Ben Lomond Mountain in the past. The rock, which is classified as quartz diorite, is a fair building material but is not being used at present.

There is a deposit of granite on Granite Creek, a branch of Branciforte Creek, in sec. 29, T. 10 S., R. 1 W., M. D., which presents a face 70 feet high in a road-cut, and from which large blocks could be easily quarried for rip-rap or similar use. The rock is a rather coarse-grained, light-colored, biotite granite containing occasional stringers of feldspar and muscovite. It is considerably fractured and shows some disintegrated granitic material in the same cut with the hard blocks. Some of the soft material has been sold to the county for road use, but the deposit is otherwise undeveloped. It is on the ranch of the three brothers, Charles P., La Salle, and Samuel Bachellor (Box 776, Route 1, Santa Cruz).

Iron

Triumph Steel Company. This company in 1926 was utilizing the black sand (magnetite) accumulated on the ocean beach, for producing sponge iron, alloy steel, and briquetted magnetite. D. M. Crist was president; J. Harris Mackenzie was secretary.

This property has a long history under various operators beginning several decades prior to the advent of Triumph Steel Company and continuing intermittently down to the limited experimental work of the present operator, Coast Metals and Reduction Company. The latter greatly reduced the scope of their work toward the end of 1942. The location is at sea-level 3 miles southeast of Aptos in T. 11 S., R. 1 E., M. D. A station called Cristo, can provide service by the Southern Pacific Railroad to the old plant building, which is still in good repair. One of the earliest reported operations was a gold placering venture which recovered some fine gold in ''heavy canvas riffles'' but did not pay expenses. Much of the apparatus used in the patented Triumph sponge iron process was of original design and manufacture. Their own steam-electric power plant provided for the magnetic separation of magnetite, ilmenite, and chromite from the dry quartz, garnet, and other waste material. A large amount of direct current was required for the reduction of metallic iron from its oxide in an atmosphere of gasified crude oil. While metallurgically successful in making several commercial products (including ferro-titanium) this company, in common with the many other operators of this deposit, was apparently unable to show a profit. A detailed description of the Triumph Steel Company's operation was made by C. McK. Laizure.[16] The property was idle when visited by the writer, but is reliably reported to be still engaged in minor experimental work here in connection with a larger plant in Canton, Ohio, also operated by Coast Metals and Reduction Company. This company is represented by A. Tregoning Cape, 251 East Schreyer Place, Columbus, Ohio. Large amounts of electric current and gas were supplied by the Coast Counties Gas & Electric Company to the latter operator during the years 1941-1942, and these service lines are still available at the plant.

Lime

The burning of lime was one of the earliest industries established in Santa Cruz County, the first kiln having been built in 1851 by I. E. Davis and A. P. Jordan. This afterward became the property of Henry Cowell, and the old pot kilns may still be seen on the Cowell Ranch alongside the road from the limestone quarry to their present kilns at Rincon.

Henry Cowell Lime and Cement Company. Officers: S. H. Cowell, president; M. H. Bresee, secretary; George Cardiff, manager at Santa Cruz; home office, 2 Market Street, San Francisco. The Cowell quarry is in sec. 34, T. 10 S., R. 2 W., M.D., 2 miles northwest of Santa Cruz and 1 mile up the canyon from the old quarry first worked by Davis and Jordan, and later by Henry Cowell. Limestone outcrops in this canyon in many places. The rock is both coarsely crystalline and fine grained, white to bluish-white in color; the coarse-crystalline variety is the most abundant.

The limestone is quarried by dry jackhammers using detachable bits and supplied with air from an assembled portable compressor. Both black powder and dynamite are used. All rock is trucked from the quarry 1.9 miles to the kilns at Rincon station on the Southern Pacific railroad. Formerly the coarse-crystalline limestone was burned in three pot kilns near the ranch house and the dense and fine-grained variety in four 34-foot standard continuous kilns at Rincon. In 1920 three new pot kilns were added to the Rincon plant and the ones near the ranch house were abandoned. The Standard continuous kilns did not work well except on the dense fine-grained rock. This variety required a greater heat for complete calcination, and the use of the continuous kilns also necessitated selective mining of the limestone to provide a suitable feed. For these reasons they are not now used and all the limestone is now burned at the Rincon plant in three pot kilns. Each kiln has a capacity of 1600 barrels and is provided with four draw doors and four burners. Fuel oil is used with steam atomization. It requires from 4 to 4½ days to burn a charge, 36 to 48 hours for cooling, and 3 days (formerly 2 days when crew was larger) to draw the burned lime. The barrels in which the lime is packed are made in a cooper shop at the Rincon plant. From 12 to 15 men are employed including several at the quarry and the balance at the kilns. In 1926 more than twice this number of men were at work.

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[16] Laizure, C. McK., Santa Cruz County: California Min. Bur. Rept., vol. 22, no. 1, pp. 82-84, January 1926.

I. X. L. Quarry. This quarry, also owned by the above company, is situated in sec. 4, T. 10 S., R. 2 W., M.D., 2½ miles northwest of Felton and half a mile north of the former Holmes Lime and Cement Company's quarry. There are three pot kilns on the property. No limestone has been quarried or burned here for the past 24 years.

Holmes Lime and Cement Company Quarry. This company no longer exists, and its former quarry is now the property of Santa Cruz County Title Company, 22 Cooper Street, Santa Cruz. The quarry is located in sec. 9, T. 10 S., R. 2 W., M.D., 2 miles northwest of Felton. The limestone is exposed along the strike northwestward from the base to the top of the mountains, about 1000 feet. Although idle since 1933 and now stripped of all equipment, this quarry was formerly an important producer. It had been opened on three faces. The considerable overburden was hauled off in dump carts. Air drills were once operated by an electrically driven compressor. The limestone was trammed from the quarry to the kilns and hydrating plant in 8-ton cars which were hauled back by horses. The rock is a white crystallized limestone, both coarse and fine grained. At the plant, which was situated below the quarry near the town of Felton, five pot kilns were in use, one of 1000 barrels capacity and four of 500 barrels. There were also two patented continuous kilns not in use since prior to 1926. Oil with steam atomization was used for burning. In addition to the burned lime, the plant was equipped with a Clyde hydrator which had a capacity of 25 tons of hydrate per day. The hydrate was bagged by a Bates valve-bag sacker. The lime barrels were made at the kiln. The quarry is an old one and had been operated more than 52 years prior to the final shutdown in 1933, when 30 men were employed.

Limestone

Pacific Limestone Products Company. Home office, plant, and quarry at Santa Cruz. Officers: Fred W. Johnson, president; D. L. Martin, vice president; M. M. Johnson, secretary. This company was organized in 1922 and took over the old Caplatzi quarry which had been operated on a small scale by former owners for many years. Since this 12½-acre property was taken over by the Pacific Limestone Products Company, the number of the raw limestone products prepared for specific purposes has been greatly increased, and they are now being sold under the trade name of Kalkar for terrazo, stucco dash, chicken grit, roofing grit, commercial filler, mortar sand, cattle calcium, poultry calcium, fertilizer, macadam, and other uses. By the installation of additional equipment at the plant and sales promotion work carried on among prospective users of raw limestone products, the company has succeeded in quadrupling the output of the quarry in the past 20 years. In 1922 production was about 125 tons per month as compared to the present average of 1200 tons per month. Complex mineral mixes for livestock and cattle now form the principal product. Of the many different salts and other minerals blended with the limestone in the latter products, only the iodine comes from California. However, the quarry itself has produced occasional rich specimens of metallic minerals, such as a seam or kidney of arsenopyrite in a calcite gangue.

The property now comprises 49½ acres, having added the adjoining 12-acre parcel, as yet unopened, on the north and having also acquired 23 acres adjoining on the south. This latter parcel was formerly known as the Miller quarry and previously as the Thurber quarry.

The *Miller Quarry* was described by Laizure[17] as having rock which varies from a coarsely crystalline white or bluish-white limestone to a finer-grained hard siliceous limerock. The small crushing plant then producing stone for macadam and concrete work has since been removed and the quarry has lain idle for the past 10 years or longer.

The working quarry and plant are located at the end of Spring Street, Santa Cruz, 2 miles northwest of the Southern Pacific depot, at an elevation of 250 feet. The deposit is a limestone rock, medium hard with very fine to very coarse crystals. The rock is shattered and broken in large masses and is bluish-white in color. The average face is 80 feet high; overburden consists of 2 to 8 feet of soil and red clay. Within recent years a new level has been opened 22 feet below the original floor and a greater selection of material thus made possible. The new level is drained by gravity flow in a deep ditch passing under the office building. The overburden is shot down with black powder to the floor of the quarry and removed by trucks. A good deal of this overburden is sold for fill material. All that is not sold is hauled to a waste dump.

Rock is blasted down with 10- to 22-foot toe holes averaging 8 to 10 feet from the face with 40 percent L. F. Extra Giant 7/8x8 dynamite. Owing to the many vertical seams a large amount of the rock is broken down without drilling. Air from a portable Schramm compressor operates several dry jackhammers using detachable bits. Pieces larger than 24 inches are plug shot and all rock is broken with 16-pound rock hammers to sizes less than 12 inches. Because of mixed impurities of magnesium and silica, all rock is hand-picked for its color, crystals, and impurities. Loading of all material is done by hand into steel skips fitted with removable aprons (for fine material) that trip from the truck-driver's seat. These skips hold from 1 to 1½ tons of rock and have a lug in each side to fit hoisting hooks on the company's ingenious patented trucks. The trucks are specially built on the Model A Ford chassis with a friction-drive cable hoist employing a worm-drive rear-axle assembly. Steering and handling are fast and flexible, since the driver faces the driving wheels with his back to the regular truck-motor installation. This converts these trucks into a front-wheel drive, rear-wheel steering vehicle, and the steering gear is a simple lever that moves to and from the driver like the stick in an airplane. After leaving an empty in its place, drivers pick up a skip loaded with the desired grade of rock and haul it some 600 feet from the working face to the primary crusher. Overburden is loaded into regular dump trucks by a similar hoist-truck having a somewhat higher lift. These special trucks burn butane gas carried in a tank placed in front of the radiator to counterbalance part of the pay-load which is all concentrated right over the driving wheels. In addition to butane gas, distillate and gasoline are also used. The plant, however, is operated entirely by multiple-unit electric motors connected by V-belts.

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[17] Laizure, C. McK., Santa Cruz County: California Min. Bur. Rept., vol. 22, no. 1, p. 86, January 1926.

The 14 by 42-inch Roller-Bear primary jaw-crusher reduces the rock to 4 inches or less. This material is then elevated about 30 feet to a trommel screen removing waste dirt and cleavage material; passed through the secondary 10 by 36-inch jaw-crusher which reduces it to 1½ inches or less; elevated 50 feet to a 100-ton working bin; thence automatically fed to a No. 2 Williams hammer mill; elevated to 3 units of Rotex 4-deck screens which make a separation of finely divided material and five sizes of granulars. The Rotex tailings go in closed circuit through a set of 12 by 16-inch rolls and drop into material from the hammer mill. Rotex screen scalpings, however, pass through a ring-roll Sturdevant mill; are elevated 35 feet and passed through a single-deck Ro-Ball screen. This material is either used as screened or passed into a 6-foot Sturdevant centrifugal air separator. Products are weighed by five automatic scales and packaged in four-lined paper bags.

The layout is simple and so arranged that the special products can be produced without any difficulty.

The plant operates the entire year. Twenty-two men constitute the average working force. Eight men are employed in the mill and sacking department, four men handle all hauling, and the rest are used in the quarry.

Bibl.: State Mineralogist's Rept. XII, p. 395; XIII, p. 631; XVII, p. 237; XXII, pp. 86-88. Pit and Quarry, vol. 10, no. 5, pp. 55-58, June 1, 1925.

Mineral Water

Although several small mineral springs occur singly and in groups within Santa Cruz County, no mineral water is bottled or commercially produced. There is little improvement at any locality except St. Francis springs (long known as Chittenden springs and later as El Pajaro springs), which was formerly a popular resort where hotel accommodations were available.

Hinns Sulphur Spring. This is a small unimproved cold sulphur spring, located near the top of Hinkley ridge about a mile east of Olive springs.

A number of other small unnamed seepages or springs of mineralized water also occur west and northwest of Olive springs.

Olive Springs. This picturesque property, which still remains practically in its natural state, comprises 100 acres, located on Hinkley Creek near its junction with Soquel Creek, and extending to the top of the ridge between the two streams.

The property is in T. 10 S., R. 1 W., M. D., and ranges in elevation from 300 feet at the camping ground to 1200 feet on the ridge. It is 6 miles north of Soquel, with which it is connected by a good road. Owner, Elizabeth Ann Corcoran, 3027 Sylvan Avenue, Oakland, California.

Hinkley Creek flows through a deep canyon here, the walls of which stand nearly vertical. Seepages and springs occur at numerous points in the creek bed and in the sandstone formation which forms the canyon walls. The rock is very soft in places and in process of decomposition.

Of probably a dozen springs on the property, five have been somewhat improved by constructing small concrete basins around them, These five are known as the White Sulphur, Sulphur, Sulphur and Iron, Magnesium, and Magnesium and Iron springs, but the names mean little. All are cold.

The so-called Magnesium and Iron spring has a flow which more than fills to capacity a 2-inch open pipe line, leading from the spring to the camp grounds. This line has a fall of 100 feet or more in a few hundred yards.

No water is sold, but visitors are permitted to carry away as much as they desire.

Table 2—Analysis of the White Sulphur Spring Water by G. A. Banks, M.D., Chemist

Constituents in parts per million.

Reaction:

Primary salinity	29
Secondary salinity	2
Tertiary salinity	0
Primary alkalinity	0
Secondary alkalinity	62
Tertiary alkalinity	?

Constituents	*By weight*	*Reacting values*
Carbonate (CO_3)	390	12.98
Sulphate (SO_4)	234	4.80
Calcium Ca	180	9.00
Sodium Na	156	6.90
Phosphate (PO_4)	0	0.00
Chloride Cl	104	2.98
Magnesium Mg	86	6.92
Potassium K	2.5	.06
Total	1152.5	

Carbon dioxide (CO_2) present
Hydrogen sulphide (H_2S) 8.2

The soft decomposed sandstone in the vicinity of the springs has been investigated with a view to utilizing it in the preparation of a cleansing compound or soap, as it is claimed to have remarkable qualities as a chemical clay. It has a soluble potash content, and a small plant was erected on the property during the period of World War I for the production of potash. A steel leaching tank and parts of what appear to be a concrete calcining furnace or evaporator remain on the ground, but as this work was carried on before the present owner took possession, the results obtained are not known. It is said that some potash was produced.

According to an anlysis by E. W. Rice, of Santa Cruz, the decomposed sandstone has the following composition:

		Percent
SiO_2	Silica	76.680
Fe_2O_3	Iron Oxide	.755
Al_2O_3	Aluminum Oxide	13.575
CaO	Lime	4.305
MgO	Magnesia	0.325
K_2O	Potash	3.265
Na_2O	Soda	1.925
Loss on ignition		3.125

St. Francis Springs. This property contains 37 acres located on the banks of Pajaro River at Chittenden Station. At least 12 cool, strongly sulphuretted springs issue at this locality along a sloping bank near the river. The springs were long known locally as *Chittenden springs.* In 1909 they were improved and opened to the public as *Shale sulphur springs.* Later the name was changed to *El Pajaro springs.*

The property is now owned by St. Joseph's Hospital, Buena Vista Avenue, San Francisco, and is called St. Francis springs. It has reverted to private use and probably will never again be opened as a public resort. The buildings have been converted to use as a seminary.

Bibl.: State Mineralogist's Rept. VIII, p. 555; XIII, p. 519; XVII, pp. 239-241; XXII, pp. 88-89; U. S. Geol. Survey Water-Supply Paper 338, pp. 272, 274-276.

Peat

Occurrence of peat in at least two places in Santa Cruz County was noted by C. McK. Laizure in 1926.[18] Ten years later in October 1936, both these occurrences were verified in considerable detail by A. P. Dachnowski-Stokes,[19] physiologist, Soil Survey Division, Bureau of Chemistry and Soils.

The latter article describes the Pajaro Valley peat lands near Watsonville as being cattail and tulereed peat of doubtful value except for storage and conservation of ground water. It states in part:

> "An area of 1,216 acres of peat land has been mapped by the Soil Survey Division (23) along Larkin Creek and its branches, among the low hills west of Watsonville. This peat land occurs in drainage channels and depressions of varying depth [soundings down to 20 feet were listed] and owes its origin to the restricted drainage caused by deposits of alluvial soil that were brought down in floods by Pajaro River and deposited across the mouth of Larkin Creek near tide level."

Concerning the Graham deposit noted by Laizure in Scott Valley near Felton, Dachnowski-Stokes says:

> "About five miles north of Santa Cruz, at an elevation of approximately 500 feet above sea level, an area of peat was sounded (Ed.—Described as sedge peat and varying in depth from 2½ to 9 feet) near the junction of the Los Gatos highway and the Mount Hermon road. The tract comprises 15 acres and is used as pasture. From a part of the area the peat is now being excavated and spread on the ground to dry. The material is prepared as a commercial organic product for soil improvement and is sold to owners of greenhouses and golf courses, and landscape gardeners in the larger cities."

While conceding that peat is organic in origin and that it is usually classed as an agricultural rather than as a mineral product, the writer includes this material in the present report on mineral resources because of the general geological interest in its deposition and evolution. Moreover, the producing deposit herein described owes much of its economic success to the fact that sales of this peat are accompanied by sales to the same buyers in approximately equal tonnage and value, of the rich, loamy top-soil overlying it.[20] Excavation and sale of soil clearly constitutes a mining operation.

Graham Ranch Peat Deposit. Owner and operator: J. J. Graham, Route No. 4, Box 299, Santa Cruz. This bog is located in sec. 25, T. 10 S., R. 2 W., M. D. Production started in 1930, reached the peak in 1936, and has averaged 1000 tons of peat annually for the past 6 years. Two large dump trucks are used, but so far no mechanical means of loading has proven successful. Hand shovelling, soft footing, and high throw (see fig. 15) make the work so arduous that the owner is unable to get steady help. The dried peat is pulverized in a hammer mill and stored in a large barn to meet orders for delivery by dump truck. The orders for top-soil, overlying the peat, are filled from small stock-piles thrown up with a Fresno scraper. Efforts to contract for the use of a long-boom drag-line shovel have been abandoned because of the large cash deposit demanded against possible damage to, or loss of, equipment. Production will probably not be greatly increased unless some mechanical loading device can be installed at a low cost.

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[18] Laizure, C. McK., Santa Cruz County: California Min. Bur. Rept., vol. 22, no. 1, p. 90, January 1926.

[19] Dachnowski-Stokes, A. P., Peat land in the Pacific Coast states in relation to land and water resources; U. S. Dept. Agriculture Misc. Pub. 248, pp. 10-13, 1936.

[20] Storie, R. Earl, Natural land divisions of Santa Cruz County, California: their utilization and adaptation: California Univ., Coll. of Agr. Bull. 638, 55 pp., July 1940.

Petroleum

There has been no commercial production of petroleum in Santa Cruz County, although small seepages of crude oil have been found and a number of wells drilled. According to Branner, Newsom, and Arnold,[21] who reported only upon that portion of the county within the Santa Cruz quadrangle:

> "Apparently the most promising locality for prospecting for oil is that along the coast west and southwest from the outcropping bituminous rock beds, since those beds pass down under overlying shale in that region. Wells drilled here, however, failed to find oil, and it is supposed that the oil which must formerly have existed in the sandstones of the region has been drained off through large fractures which extended from the surface of the shale down to the underlying sandstone. Many sandstone dykes, some of them of large size, occur along the coast in this region. These were formed from the underlying oil-bearing sandstones and the larger ones probably represent the channels through which the oil from the underlying strata escaped."

The geology and oil possibilities of the county are further discussed by Vander Leck,[22] who says:

> "In the area around Ben Lomond Mountain, running from Little Basin to the town of Santa Cruz, the formations consist of granitic rocks, together with areas of ancient crystalline schists. In the region to the north of this crystalline area there are outcrops of the San Lorenzo formations, the Vaqueros sandstone and the diatomaceous shale of the Monterey. These have been all sharply folded and faulted. The Monterey contains numerous seepages, but there is an almost total lack of an overlying formation which could act as a reservoir. This, together with the unfavorable structural conditions, make the possibility of obtaining oil in paying quantities in this area remote. In some cases, by reason of faulting, the oil has migrated from the Monterey into the underlying beds of the Vaqueros and San Lorenzo. It is probable that wells drilled in this area in either the Monterey, or the underlying Tertiary beds will encounter small showings of oil, but not of sufficient size to be of commercial importance.
>
> "In the area between Ben Lomond Mountain and the coast, the Vaqueros and Monterey lie in a monocline, dipping about 25° to the southwest. The Monterey is heavily bituminized and has been extensively quarried for asphaltum.
>
> "The remainder of the county, which embraces the district lying between Santa Cruz and Watsonville and southwest of the Santa Cruz Mountains, may be likened to a coastal plain. In the country north of Aptos this likeness is not generally apparent, as the hills frequently rise to a height of 1500 to 1800 feet. Between Aptos and Watsonville, however, the county is characterized by low rolling hills, varying in elevation from 100 to 500 feet. The northeast boundary is marked by the steep escarpment of the west side of the Santa Cruz Mountains, formed by the San Andreas fault. The greater portion of the district is covered by loose incoherent sands and clay, varying in color from yellow to brown and having no distinctive strike or dip. The age is not definitely known, but very probably they belong to the Merced formation (upper Pliocene). With the exception of an area about three miles northeast of Watsonville (which will be discussed below) no distinctive structure could be made out in these beds. Near the town of Santa Cruz, the Monterey shale apparently dips under the Merced beds and very probably it underlies this entire area. Between the San Andreas fault and the Santa Clara County line, is an area of Monterey shale, referred to in the article on Santa Clara County. The shale apparently lies in a synclinal trough; the eastern limb resting on the Franciscan; the axis of the syncline approximately coinciding with the county line and the west limb is faulted against the Merced beds by the San Andreas fault.
>
> "On the Mount Madonna road, about four miles north of Watsonville and about one-half mile south of the Casserly school, is the axis of a small anticline in the Merced beds, the west limb of which is sharply compressed against the Monterey shales by the San Andreas fault. It is in this area that the indications of oil occur. On the Webb Ranch, it is reported that two shallow wells were drilled and obtained gas. In the canyon just back of the ranch house there is apparently a dry seepage of black oil. On the Hughes Ranch, one well was drilled up the canyon just back of the house. A depth of 700 feet was reached and considerable gas was encountered. At the present time

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[21] Branner, J. C., Newsom, J. F., and Arnold, Ralph, Description of the Santa Cruz quadrangle, Cal.: U. S. Geol. Survey Geol. Atlas, Santa Cruz folio (no. 163), 11 pp., 1909.

[22] Vander Leck, Lawrence, Petroleum resources of California: California Min. Bur. Bull. 89, pp. 66-68, 1921.

(1921) the Cymric Oil Company is drilling a well (Ed.: 1500 feet deep. Dry hole.) at this location. This area may be considered as worthy of being tested. As regards the remainder of the area under discussion it is worthy of being thoroughly investigated for structure before being condemned. It is apparently underlaid by bituminous shales of the Monterey and should detailed mapping reveal any favorable structure in the Merced beds, the locality would be worth testing."

The following data regarding prospect wells drilled within the county from 1914 to 1943, inclusive, are from records compiled by the State Oil and Gas Supervisor.[23]

Table 3

Company	Well	Sec.	Twp.	R.	Date started	Depth	Abandoned
Cymric Oil Co.	1	14	11 S.	2 E.	1921	1,500	Yes
Joseph Faria, Jr.	1	12	11 S.	3 W.	1939	533	1939
Greater Santa Cruz Oil Corp.#	1	5	11 S.	1 W.	1924	3,943	1932
Lee Oil Co., Ltd.	1	14	11 S.	2 E.	1927	2,889	1933
Frank Marik	1	18	11 S.	2 E.	1926	1,440	Yes
Monterey Bay Oil Co.	1	22	11 S.	2 W.	1922	1,200	Yes
Monterey Bay Oil Co.*	2	22	11 S.	2 W.	1923	7,000 plus	drilling
Alan W. Rispin	1	14	11 S.	2 E.	1930	----------	Yes
Rhoads & Schmitt	1	17	9 S.	1 W.	1918	1,000	Yes
Gerard Ryzek	1	14	11 S.	2 E.	1926	680	1940
M. P. Shepherd	1	14	11 S.	2 E.	1930	685	Yes
Skookum Oil & Investment Corp., Inc.	1	19	11 S.	2 W.	1930	----------	Yes
Swanton Improvement Co.	1	23	11 S.	2 W.	1925	712	1927
United Royalties Co.	1	16	11 S.	2 E.	1924	950	1927
C. W. Wright	1	27	8 S.	2 W.	1939	990	1941

# Formerly Santa Cruz Laveaga Trust Oil Company.

* The Monterey Bay Oil Company (formerly Danish Oil & Development Company) well No. 2 listed above is drilling in its 21st year and is now 7,000 feet deep. Mr. Fred A. Philbrick has been the driller since the well was spudded in, and he reports occasional oil showings throughout the entire log. A picture of this wildcat taken in January, 1943, accompanies this report and shows steam up in the boiler (fig .16).

Other current reports on oil seeps or oil showings in water wells include:

Mrs. P. D. Smith, R. D. 4, Box 445, Santa Cruz. Has oil scum on a water spring on her acreage in sec. 9, T. 10 S., R. 2 W., M.D. This property is at Ben Lomond, near Hatfield's Camp and is at the junction of Newell Creek and San Lorenzo River on the Quail Hollow road.

Miss T. Hihn, Box 86, Aptos. An oil seep has ruined a water well on her ranch property in the Valencia district, 3½ miles northeast of Aptos.

Stone Industry: Crushed Rock, Sand and Gravel

Except at the plant of the Pacific Limestone Products Company (see under Limestone) where a small tonnage of a siliceous dike rock is sorted out for macadam and concrete, there are no commercial rock-crushing plants within the county. There are only two producers of washed and sized sand and gravel; all other material of this kind produced being bank run.

Henry J. Kaiser Co., Inc. (Olympia Sand Pit.) Home office, 1522 Latham Square Building, Oakland, California; plant superintendent, Donald C. Tretzel, Box 102, Felton. This plant is situated in sec. 11, T. 10 S., R. 2 W., M.D., at Olympia on Zayante Creek and about a mile from the present end of the railroad to the north. The property contains some 60 acres and adjoins the land of Pacific Coast Aggregates, Inc. in sec. 14.

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[23] Bush, R. D., Result of wildcat drilling in California, 1914-1924. California Oil Fields, vol. 11, no. 1, pp. 5-28, July 1925.

Operations were started in June 1937 and the production has since averaged well over 100,000 tons per year. Estimated reserves are 3,500,000 tons. The white sand includes but little gravel. It is well compacted, increasing 67 percent in volume upon being shot down. Two 16-foot bottom holes are drilled by hand with a 5-inch auger, loaded with 120 pounds of dynamite each, and shot together. The present face varies from 50 to 100 feet. Loose material is recovered by a 100-h.p. hoist and drag scraper and moved on an 18-inch conveyor belt 400 feet long to a storage hopper at plant. The latter guards against minor pit delays since storage rate is 200 tons per hour and plant consumption only 120 tons per hour.

From storage hopper, material moves on the 150-foot long 30-inch main conveyor belt to the head chute where the first water is added; to double-deck Niagara 4 by 12-foot screen with ⅜-inch cloth in top deck, and about ⅛-inch in bottom. Material over ⅜-inch is wasted. The minus ⅜-inch to plus ⅛-inch is sold as pea gravel for the production of concrete sand. The minus ⅛-inch material is blended into three types of commercial sand. It goes into four revolving screens which separate minus 10 mesh, minus 20 mesh, and minus 30 mesh; from the revolving screens into a 12 by 36-foot Bodison classifier where the material is washed. Then into four chutes, each with four gates, where the sand is blended into the following finished products: No. 1 plaster sand, No. 2 plaster sand, concrete sand, and asphalt sand. Overflow of water from Bodison classifier goes into a bowl thickener settling fine sands used in asphalt sand. From the 16 gates mentioned above, material gets the final wash in a 16 by 32-foot Dorr classifier to stockpiles. All material loaded out for shipment is handled by an Industrial Brownhoist No. 7 clamshell with a 1¾-yard bucket. Except truckloads filling local orders, shipments are made via Southern Pacific railroad in sideboarded flat cars, hoppers, and gondolas. Available fresh water from surface sources is used at the rate of 600 gallons per minute and this is combined with 1000 gallons per minute of reclaimed water from a Dorr hydro-separator 50 feet in diameter and 10 feet deep. Hydroseparator tailings are pumped into a series of four settling ponds whence the fresh water is further clarified by treatment with burnt-lime (produced in Santa Cruz County) before being released into Zayante Creek. A fifth settling pond acts as a reserve for emergencies. In flood seasons, as when visited, these sand plants are permitted to release and clean out the accumulated tailings in all ponds. A crew of seven men is employed. At least 95 percent of present production of these adjoining plants goes directly into war construction work.

Pacific Coast Aggregates, Inc. Home office, 85 Second Street, San Francisco; plant superintendent, L. H. Chase, Route 4, Box 386, Santa Cruz. This plant is located in sec. 14, T. 10 S., R. 2 W., M. D., at Olympia on Zayante Road. The total holdings comprise nearly 80 acres.

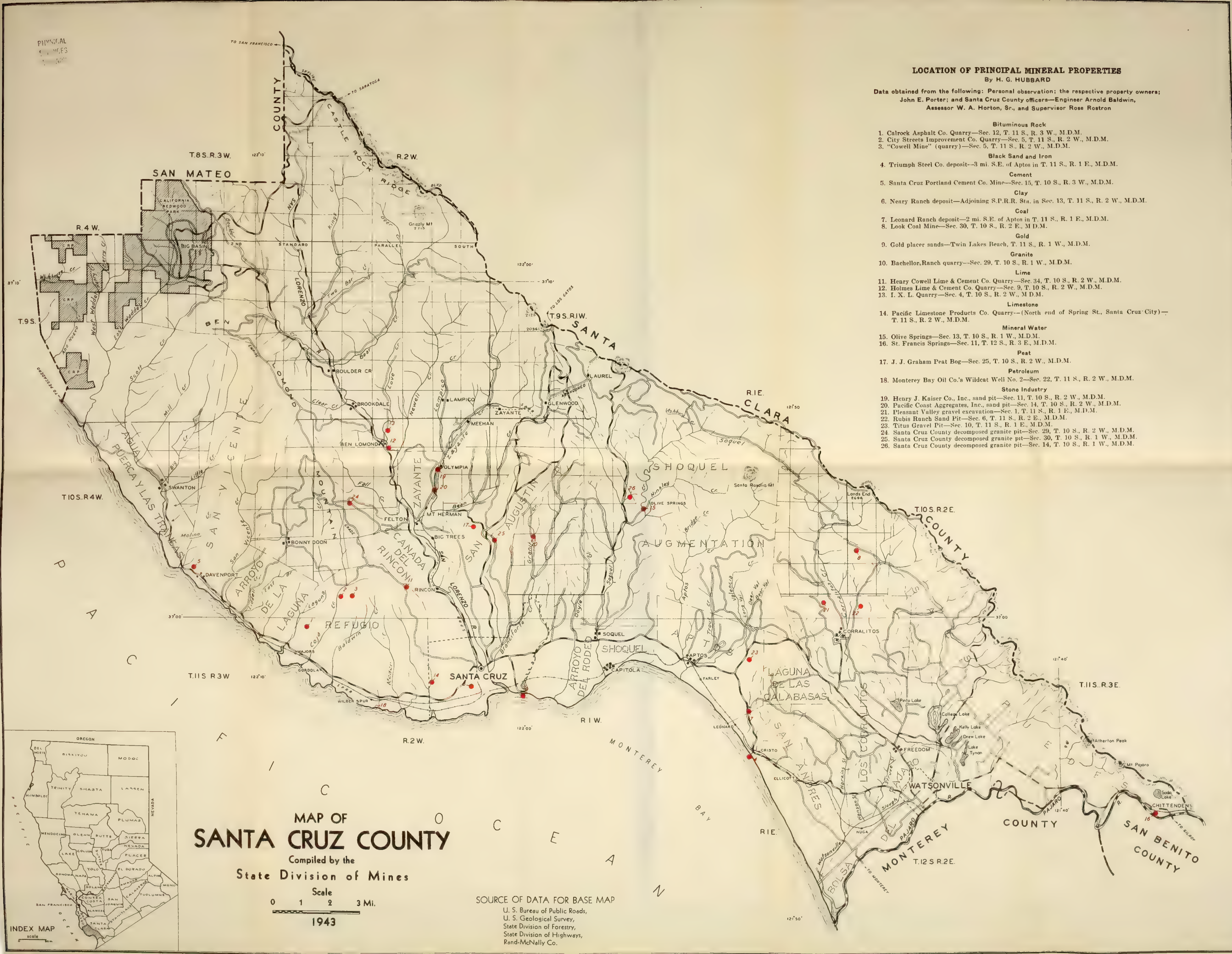
This pit has been worked since 1928 and has an average annual production of 100,000 tons. It is separated from the actual operations on the adjoining Henry J. Kaiser Co., Inc. land by only a few hundred yards, and resembles the latter workings in so many respects (products, capacity, methods, plant, number of men employed, and others) that only some of the major differences will be listed here and the reader is referred for details to the paragraphs immediately preceding. Bunkers, rather than stockpiles, are used here. Shooting is chiefly confined to one big blast which brings down a year's supply of material. For several years past, this annual tunnel shot has been successfully made in cooperation with Al Clough of the Atlas Powder Co. The blast-tunnel is driven into the bottom of the face for 75 feet and 50-foot wings are then run to right and left, parallel to the face. From 9 to 10 tons of black powder are used to blast down from 100,000 to 125,000 tons of sand. Material goes to the plant on three conveyors, with a sizing screen on the second conveyor removing and wasting all plus 1-inch material; the minus 1-inch goes up another conveyor to a vibrating screen, whence the plus ½-inch to minus 1-inch product is saved as gravel. The minus ½-inch is divided between two machines. One is a rake classifier and the other a screw classifier. The resulting four products are the same as those obtained by Henry J. Kaiser Co., Inc.; the chief difference in the plants being that Pacific Coast Aggregates has ample fresh water from its own springs and reservoir so that no hydro-separator is required. Its No. 1 blending sand is sold to blend with concrete sands of other plants that lack sufficient fines. For emergency use, this company maintains small stockpiles and employs both a Brownhoist and a P. & H. crane. The peak production here was 150,000 tons in one year. Known reserves exist for many years of operation at present rate.

Pleasant Valley Excavation. Owners of the two adjoining ranches are William L. Alvein, Route 1, Box 43, Aptos, and Walter E. Vass, Route 1, Box 42, Aptos. This property is located in sec. 1, T. 11 S., R. 1 E., M. D., about 1½ miles northwest of Corralitos. Two power shovels are loading dump trucks with select material rather than bank run gravel for use as fill on the Watsonville Municipal Airport. The operation is part of an army contract and a total of 156,000 tons is to be taken on a royalty basis. Shovels are moved along the low face of the bank being worked wherever the desired class of material appears. It is not probable that this gravel deposit will be worked to any large extent after the tonnage required for the present job has been removed.

Rubis Sand Pit. Located in sec. 6, T. 11 S., R. 2 E., M. D. on the old Rubis Ranch 1½ miles northeast of Corralitos. This deposit has been worked intermittently by different owners of the ranch and the material resembles that in the two Olympia sand pits. Idle when visited.

Titus Gravel Pit. Owner, John W. Titus, Route 1, Box 19, Aptos. This property is situated in sec. 10, T. 11 S., R. 1 E., M. D., on the Santa Cruz-Corralitos highway about a mile northeast of its junction with the Aptos-Robroy and Cristo road. Bank-run gravel of mixed size is barred down and loaded by a small gasoline-powered drag-scraper into dump trucks as needed to fill orders. The present face is about 40 feet and but little tonnage has been removed from what appears to be a fairly large deposit.

In addition to the above, other firms and individuals occasionally dig sand and gravel from various points on San Lorenzo River, Corralitos Creek, or the Monterey Bay beaches, loading direct to trucks.


TO SAN FRANCISCO
TO SARATOGA
COUNTY
SAN MATEO
T.8S.R.3W.
R.2W.
R.4W.
CASTLE ROCK RIDGE
CALIFORNIA REDWOOD PARK
BIG BASIN
Grizzly Mt
STANDARD
PARALLEL
SOUTH
T.9S.
T.9S.R.1W.
TO LOS GATOS
SANTA
CLARA
COUNTY
R.1E.
BEN LOMOND
LORENZO
BOULDER CR
BROOKDALE
LAMPICO
ZAYANTE
GLENWOOD
LAUREL
MEEHAN
OLYMPIA
FELTON
MT HERMAN
BIG TREES
BONNY DOON
SWANTON
DAVENPORT
RINCON
T10S.R4W.
AGUA PUERCA Y LAS TRANCAS
SAN VICENTE
ARROYO DE LA LAGUNA
REFUGIO
CANADA DEL RINCON
MOUNTAIN
SAN AUGUSTIN
SHOQUEL
AUGMENTATION
APTOS
OLIVE SPRINGS
Santa Rosalia Mt
Lands End
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CORRALITOS
SOQUEL
CAPITOLA
SANTA CRUZ
WILDER SPUR
MAJORS
GORDOLA
T.11S R3W
R1W.
R.2W.
LAGUNA DE LAS CALABASAS
SAN ANDRES
LOS CORRALITOS
BOLSA DEL PAJARO
WATSONVILLE
FREEDOM
College Lake
Kelly Lake
Drew Lake
Lake Tynan
Pinto Lake
LEONARD
CRISTO
ELLICOTT
NUGA
Atherton Peak
Mt Pajaro
CHITTENDEN
Soda Lake
T.11S.R.3E.
T.12S.R.2E.
MONTEREY
COUNTY
SAN BENITO COUNTY
TO GILROY
TO MONTEREY
MONTEREY BAY
R1E.
PACIFIC OCEAN
37°10'
37°00'
122°00'
122°10'
121°50'
121°40'
INDEX MAP

MAP OF
SANTA CRUZ COUNTY

Compiled by the
State Division of Mines

Scale
0 1 2 3 Mi.

1943

SOURCE OF DATA FOR BASE MAP
U. S. Bureau of Public Roads,
U. S. Geological Survey,
State Division of Forestry,
State Division of Highways,
Rand-McNally Co.

LOCATION OF PRINCIPAL MINERAL PROPERTIES

By H. G. HUBBARD

Data obtained from the following: Personal observation; the respective property owners; John E. Porter; and Santa Cruz County officers—Engineer Arnold Baldwin, Assessor W. A. Horton, Sr., and Supervisor Rose Rostron

Bituminous Rock

1. Calrock Asphalt Co. Quarry—Sec. 12, T. 11 S., R. 3 W., M.D.M.
2. City Streets Improvement Co. Quarry—Sec. 5, T. 11 S., R. 2 W., M.D.M.
3. "Cowell Mine" (quarry)—Sec. 5, T. 11 S., R. 2 W., M.D.M.

Black Sand and Iron

4. Triumph Steel Co. deposit—3 mi. S.E. of Aptos in T. 11 S., R. 1 E., M.D.M.

Cement

5. Santa Cruz Portland Cement Co. Mine—Sec. 15, T. 10 S., R. 3 W., M.D.M.

Clay

6. Neary Ranch deposit—Adjoining S.P.R.R. Sta. in Sec. 13, T. 11 S., R. 2 W., M.D.M.

Coal

7. Leonard Ranch deposit—2 mi. S.E. of Aptos in T. 11 S., R. 1 E., M.D.M.
8. Look Coal Mine—Sec. 30, T. 10 S., R. 2 E., M.D.M.

Gold

9. Gold placer sands—Twin Lakes Beach, T. 11 S., R. 1 W., M.D.M.

Granite

10. Bachellor Ranch quarry—Sec. 29, T. 10 S., R. 1 W., M.D.M.

Lime

11. Henry Cowell Lime & Cement Co. Quarry—Sec. 34, T. 10 S., R. 2 W., M.D.M.
12. Holmes Lime & Cement Co. Quarry—Sec. 9, T. 10 S., R. 2 W., M.D.M.
13. I. X. L. Quarry—Sec. 4, T. 10 S., R. 2 W., M.D.M.

Limestone

14. Pacific Limestone Products Co. Quarry—(North end of Spring St., Santa Cruz City)—T. 11 S., R. 2 W., M.D.M.

Mineral Water

15. Olive Springs—Sec. 13, T. 10 S., R. 1 W., M.D.M.
16. St. Francis Springs—Sec. 11, T. 12 S., R. 3 E., M.D.M.

Peat

17. J. J. Graham Peat Bog—Sec. 25, T. 10 S., R. 2 W., M.D.M.

Petroleum

18. Monterey Bay Oil Co.'s Wildcat Well No. 2—Sec. 22, T. 11 S., R. 2 W., M.D.M.

Stone Industry

19. Henry J. Kaiser Co., Inc., sand pit—Sec. 11, T. 10 S., R. 2 W., M.D.M.
20. Pacific Coast Aggregates, Inc., sand pit—Sec. 14, T. 10 S., R. 2 W., M.D.M.
21. Pleasant Valley gravel excavation—Sec. 1, T. 11 S., R. 1 E., M.D.M.
22. Rubis Ranch Sand Pit—Sec. 6, T. 11 S., R. 2 E., M.D.M.
23. Titus Gravel Pit—Sec. 10, T. 11 S., R. 1 E., M.D.M.
24. Santa Cruz County decomposed granite pit—Sec. 29, T. 10 S., R. 2 W., M.D.M.
25. Santa Cruz County decomposed granite pit—Sec. 30, T. 10 S., R. 1 W., M.D.M.
26. Santa Cruz County decomposed granite pit—Sec. 14, T. 10 S., R. 1 W., M.D.M.

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DISCOVERIES IN THE STRATEGIC MINERALS, SAN FRANCISCO FIELD DISTRICT

By C. McK. Laizure*

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In connection with applications to the Reconstruction Finance Corporation for preliminary mining loans (Class C loans) the Engineers of the Division of Mines have visited a number of proposed new operations in strategic minerals during 1942.

The following notes cover these in the San Francisco Field District.

ALAMEDA AND SAN JOAQUIN COUNTIES

Manganese

Wolfe and Aitkin Lease. This lease covers four patented sections near Arroyo Mocho in the Tesla Mining District, about 25 miles from Livermore. Owners are Chas. D. Scott (secs. 26 and 34, T. 4 S., R. 4 E.; and sec. 4, T. 5 S., R. 4 E., M. D.) and the Winship Estate (sec. 27, T. 5 S., R. 4 E., M. D.) of Mocho, Alameda County.

Development of five or six closely grouped outcrops of manganese oxide ore in sec. 34 is planned. Four miles of bulldozer road built by lessees provides access.

A good chromite outcrop is reported on sec. 26, but work now planned is limited to manganese operations.

The property was leased in May 1942 by Wolfe and Aitkin, 804 Kohl Bldg., San Francisco.

FRESNO COUNTY

Tungsten

Al Feuerstein Property. This property (elevation 1600 feet) comprises 80 acres of deeded land leased from the Spence Estate, Fresno, California. Lessee is Al Feuerstein, 3863 Kerckhoff St.,

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* District Mining Engineer, Division of Mines, San Francisco Field District.

Fresno, California. The location, in sec. 15, T. 11 S., R. 24 E., M. D., is on oiled road 2½ miles east of Tollhouse post office.

The deposit is metamorphic, in or near the contact of crystalline limestone with granite. Ore is scheelite, showing considerable high-grade, in a gangue of quartz-garnet-epidote and some calcite. Little work has been done. Outcrops indicate a 4½- to 5-foot vein extending 3000 feet and splitting into a branch vein 3½ feet wide, exposed for 300 feet.

The lessee plans immediate (May 17, 1942) installation of a 10-ton mill.[1]

LAKE COUNTY

Chromite

Hull Mountain Chrome Mine. This mine is in sec 36, T. 19 N., R. 10 W., M. D., about 6 miles by road northeast of Lake Pillsbury. It is owned by A. M. Akins and J. D. Dondero of Lakeport, and is leased to Toy L. Young, 911 12th St., Oakland.

The deposit occurs in a serpentine belt on the west side of Hull Mountain, and is opened by three opencuts. On the dump of the largest cut is a pile of approximately 50 tons of good grade chrome ore, mined last year. A road was put in this summer (1942) from a former C. C. C. camp about a mile north of the property. Mr. Young expects to start working and shipping as soon as he can make arrangements for equipment and labor, and road conditions permit trucking.

Manganese

Gravelley Valley Manganese Mine. This property is in sec. 3, T. 18 N., R. 10 W., M. D., about 1 mile west of Lake Pillsbury and about 35 miles by road from Ukiah, the nearest rail point. It is owned by Wayne P. Burke and Newell Rawles, both of Ukiah, and is leased to Toy L. Young, 911 12th St., Oakland.

The ore is on the north side of a steep east-trending gully, and outcrops for a distance of 150 feet. It has been opened by two tunnels and several small cuts, all of which show manganese ore. The upper tunnel is in about 30 feet, and cuts a 3-foot ledge of good ore 10 feet from the mouth. The face of this tunnel is in about 1 foot on another vein of good ore. The lower tunnel, about 15 feet in length, only shows ore at the portal. The wall rock is a laminated siliceous rock, the laminations being parallel to the orebodies.

The workings are about 1000 feet west of U. S. Forest Service Poker Flat Public Camp.

A road has been built to the mouth of the tunnel. In building it another vein of manganese was uncovered, on which an open cut has been made. From this cut one car of ore has been shipped to the stockpile at Sacramento, and another has been mined and made ready to ship as soon as weather and road conditions permit. Two men are at work on the property.

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[1] A card from Feuerstein, Dec. 15, states mill is in operation.

MADERA COUNTY

Manganese

Beechnut Claim. This claim is at the center of the S½ sec. 6, T. 6 S., R. 22 E., M. D., on a good road, near Sugar Pine, at an elevation of 5,000 feet. The owner is J. R. Hossack of North Fork, California.

The deposit is reported to show 25 tons of good grade pyrolusite in a hill-top 'blow-out.' It is easily accessible for open-pit operations. Only discovery work has been done.

Tungsten

Victory Group. This group of two claims is situated near a good road in the W½ sec. 20, T. 6 S., R. 22 E., M. D., at an elevation of 4000 feet. J. R. Hossack of North Fork plans immediate trenching of small scheelite showings in a garnet gangue.

MENDOCINO COUNTY

Manganese

Foster Mountain Mine. This property, in sec. 3 or 4, T. 18 N., R. 12 W., M. D., is now owned by T. Carpenter of Ukiah, and W. B. Van Horn and C. E. Gordon of Willits, who relocated it in 1939. They shipped 5 cars of manganese ore, averaging 36 to 48 percent manganese to Sacramento in 1942, and are working through the winter on the property. They do not expect to ship any more ore until late spring, owing to the condition of the road throughout the winter.

NAPA COUNTY

Quicksilver

Toyon Quicksilver Mine. This mine is near Aetna Springs in Pope Valley about 35 miles from St. Helena by road—the last 10 miles a fair dirt road in summer.

There are two cave-ins in the main working tunnel 75 feet and 314 feet from the portal. As the first ore is 140 feet in, none was seen in place. The tunnel is near the southeast corner of the property and from the hill above the tunnel the serpentine contact with the sandstone is easily seen. From surface indications it appears that all of the workings are in the sandstone. Ore picked up on the dump was a finely crystallized cinnabar disseminated through the sandstone.

The mine lies about midway between the Oat Hill Mine (the largest mine in Napa County as to past production) and the Aetna Mine (another large producer), and it is in the same formation (sandstone) as the Oat Hill.

The Toyon mine has produced only 145 flasks of quicksilver in the last 10 years, but it has been a one-man operation mostly, and never have there been more than five men employed, due to lack of capital.

It is now being reopened by Wm. C. Baxter of St. Helena.

SONOMA COUNTY

Alunite

The development of a process of producing aluminum from western alunites lends interest to the occurrence of alunite in Sonoma County.

Frazier Property. This property is near the top of Triniti Peak on the ridge between Sonoma and Napa Counties, in the E½ sec. 1, T. 6 N., R. 6 W., M. D., about 5 miles from Glen Ellen by road; it is owned by A. W. Frazier of Glen Ellen.

Alunite occurs in a fracture zone 50 to 75 feet wide and several hundred feet long, as a filling material in seams which are from an inch to several feet in width, and as a cementing material of the surrounding breccia. The deposit has been opened by several trenches 5 to 7 feet deep, which range up to 20 feet in length. The country rock is an altered flow trachite which has been opalized in places. Overlying the trachite is a white volcanic ash.

Two small shipments of the volcanic ash were made to a soap manufacturer in San Francisco several years ago. This was mined some distance from the alunite. The following analysis was made by the Standard Chemical Company of Oakland, California, on water-soluble alum leached from the alunite after roasting, by Mr. Frazier, at the ratio of 1,300 pounds of alum to a ton of alunite. Traces of cinnabar were found in the alunite, volcanic ash, and surrounding country rock, but no commercial ore of quicksilver was found. The cinnabar is only thinly disseminated.

ANALYSIS

Water Insoluble Matter	0.02%
*Aluminum Oxide (Al_2O_3)	11.40%
Iron Oxide (Fe_2O_3)	None
Calcium Oxide (CaO)	Trace
Magnesium Oxide (MgO)	0.16%
Potassium Oxide (K_2O)	9.26%
Sodium Oxide (Na_2O)	0.18%
Sulphur Trioxide (SO_3)	33.55%
Chlorine (Cl)	0.07%
Moisture	45.36%
Total	100.00%
pH Value (1% Solution)	4.2
*Basic Alumina (Al_2O_3)	0.71%
Combined Alumina (Al_2O_3)	10.69%
Total Alumina (Al_2O_3)	11.40%

COMPOSITION BASED ON ABOVE ANALYSIS

Potash Alum ($Al_2(SO_4)2K_2SO_4 24H_2O$)	93.51%
Sodium Alum ($Al_2(SO_4)3Na_2SO_4 24H_2$)	1.80%
Aluminum Sulphate ($Al_2(SO_4)3.18H_2O$)	3.02%
Basic Alumina (Al_2O_3)	0.71%
Magnesium Sulphate ($MgSO_4 7H_2O$)	1.02%
Sodium Chloride (NaCl)	0.12%
Water Insoluble Matter	0.02%
Total	100.00%

Chromite

Laton Claims. A. J. Laton of Cazadero has located claims on a low-grade chromite deposit in SE¼ SE¼ sec. 13, T. 9 N., R. 12 W., M. D., 7 miles north of Cazadero. Estimates of 15,000 to 20,000 tons of ore are reported to have been made for the deposit. Work has been started and Laton is planning a mill.

Manganese

Aho Property. This property, 7 miles west of Cazadero, has produced ''three or four carloads'' of manganese ore during 1942, but is not being worked at present. Ore was hauled 31 miles to the railroad at Forestville. Albert Aho, Cazadero, is the owner.

Jack Boyse, Cazadero, has recently reported finding manganese prospects near that place. No work has been done yet.

Skaggs Springs Property. R. J., A., and F. O'Connell of San Francisco have sub-leased from other lessees a part of the Skaggs Springs property for the purpose of prospecting an occurrence of manganese oxide in sec. 24, T. 10 N., R. 11 W., M. D., a short distance north of the resort and west of the county road. Manganese is reported to outcrop at intervals for a length of 2500 feet in jasper beds up to 75 feet wide. Work had just begun (July 1942) to open a prospect near the creek level, from which substantial backs could be obtained. Two men were employed.

STANISLAUS COUNTY

Magnesite

Promberger Property. After long negotiations, John Promberger, 2355 Polk St., San Francisco, et al., have obtained a purchase contract on 991 acres of patented land situated 14 miles west of Patterson. The property is on Del Puerto Creek and is crossed by the road following the road-bed of the former Patterson and Western Railroad to the foot of Red Mountain.

The deposit shows on the surface for a width of 700 to 1000 feet, and for a length of nearly 2 miles.

The material is soft hydromagnesite which can be dug with a spade. It shows no change in character in the face of the longest tunnel (about 100 feet in length). Mining would be done by open cut and carryall.

The material carries about 25 percent silica, and for this reason has been passed over by former investigators; but the present owners state that the silica can all be removed by a simple log-washing operation. If this will produce a satisfactory product the deposit may possibly develop into the largest in this country.

TULARE COUNTY

Tungsten

White River Lode Mine. This mine is on 320 patented acres, in the S½ sec. 32, T. 24 S., R. 29 E., M. D., adjoining the Eclipse mine. It is on a good road 2 miles southwest of White River, at an elevation of 1200 feet. It has been leased to H. A. Records by H. G. Vincent, owner, Star Route No. 1, Porterville.

The deposit is primary and occurs at the contact of pegmatite-aplite with granite and slate. Quartz stringers contain scheelite and considerable chrysocolla. A crystalline limestone ledge carrying lead and silver intersects the tungsten formation near the aplite outcrop. Assays as high as 7.5 percent WO_3 and 6.3 percent copper are reported.

Development consists of several open cuts and a 10-foot adit totaling 133 cubic yards. Equipment includes a mobile I-R 2-stage gasoline-driven compressor unit, two jackhammers, and a ''No. 10'' caterpillar.

The lease includes facilities of a 40-ton gold mill and ample water flow in an abandoned shaft of the Eclipse Mine 100 yards from the White River Lode workings. Two men are employed.[2]

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[2] Nov. 15, we are informed production of scheelite concentrate has begun; and that with depth copper sulphides are showing.

LOS ANGELES FIELD DISTRICT

CURRENT NOTES ON ACTIVITY IN THE STRATEGIC MINERALS, LOS ANGELES FIELD DISTRICT

By W. Burling Tucker* and R. J. Sampson**

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INYO COUNTY

Antimony

Bishop Antimony Mine. This mine, comprising 6 claims, is situated on the west side of Owens Valley, 4½ miles south of Bishop; the owner is Mr. Munsinger of Bishop; the property is leased to R. S. Beatty, 7005 Melobar Street, Huntington Park, California.

While there are no satisfactory exposures of wall rock either on the surface or underground, the deposit appears to occur in a fault fracture along the contact of a rhyolite dike and crystalline limestone. This fault fracture strikes east and has a vertical dip. Its average width, where opened, appears to be about 7 feet, and it is filled with a clay gouge. The ore, which is stibnite, occurs as irregular pods in this gouge. These pods dip in any direction between the walls. They range up to 8 feet in length along the dip, up to 2½ feet in width, and about the same in length. In places, the whole mass from wall to wall is black, indicating that it may all be low-grade ore.

The property has been developed by a 70-foot vertical shaft which is connected with an adit driven east 175 feet to the shaft on the 60-foot level. On this level there is also a drift west 60 feet. All of these workings are timbered and lagged. Ore has been stoped west of the shaft for a length of 20 feet and a height of 15 feet. At 35 feet west of the shaft, a drift is being driven west, one set (about 7 feet) under the floor of the level. At present only the high-grade pods are being removed for shipment.

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* District Mining Engineer, Los Angeles Field District, California State Division of Mines.

** Assistant District Mining Engineer, Los Angeles Field District, California State Division of Mines.

Manuscript submitted for publication December 31, 1942.

The mill, which is about 100 feet east of the shaft, is connected with the head-frame by a trestle. Ore to bin, screw conveyor to 6-inch by 9-inch jaw crusher, to 4-foot by 3-foot Marcy type ball mill in closed circuit, with Simplex Dorr type drag classifier, the overflow from which is fed to a conditioner by a screw conveyor; from conditioner to 2 Denver Sub-A flotation cells to elevator to steel drying troughs. Power is supplied by a gas engine with electric motors on the classifier and flotation cells.

Seven men are working.

Lead-Silver-Zinc

Argenta Mine. Owners are George G. Gneist and Ed. L. Wright, P. O. Box 10, Trona; the property is under lease to H. T. Kaplin and Sam Nastor, Los Angeles; George G. Gneist is superintendent. The mine is in Wildrose Mining District in T. 19 S., R. 45 E., M. D., 10 miles north of Wildrose, at an elevation of 5500 feet, on a ridge north of Wood Canyon on the west slope of Panamint Mountains. It was first located in 1924, operated by Rainbow Mining Company in 1925 and by Southwestern Lead Corporation, during 1927 and 1928. As relocated by the present owners in 1930, it consists of 9 claims, covering 6000 feet along the lode. The orebody is a replacement deposit on the contact of limestone with schist and quartzite; the veins carry galena, lead carbonate, zinc carbonate, and sphalerite; vein filling is calcite and iron-manganese-stained limestone. The vein is 6 to 12 feet in width, strikes east and dips 75° N. There is a 30-foot shaft on top of the ridge, and a crosscut tunnel giving depth of 350 feet below outcrop. This crosscut tunnel is in 630 feet, and at 560 feet from the portal there is a drift driven 123 feet N. 49° E. on the limestone-quartzite contact. Zinc ore in an opencut south of the shaft (width 5 feet) is stated to assay zinc, 17 percent; silver, 1.3 ounces; lead, 2 percent. Seventy tons of lead ore shipped assayed 27 percent lead, gold and silver $8.00. Average grade of ore is stated to assay zinc, 12 percent; lead, 5 percent; silver, 2.80 ounces; gold, 0.08 ounce. Equipment includes machine shop, electric-light plant with Fairbanks-Morse gas engine, Ingersoll-Rand portable compressor, assay office, boarding and bunk houses.

Tungsten

Black Monster Group. These 3 claims are on the east slope of Coyote Ridge, about 4½ miles east of the South Fork of Bishop Creek, on the headwaters of the West Fork of Coyote Creek, about 13 miles southwest of Bishop; elevation is 10,500 to 11,300 feet; owners are M. Rossi and William Skinner, of Big Pine, and Robert and J. F. Brackett, P. O. Box 458, Bishop, California.

The country rocks are granodiorite and limestone. On the north end of the property the contact strikes north. On the south end, the limestone forms the south half of the top of a peak, dipping to the south and apparently passing into the ganodiorite about half way down the mountain. The contact is marked by a silicate zone 50 or 60 feet in width. The west or granitic side shows a fine-grained diorite which shades into the garnet-epidote mass through which the scheelite is disseminated. A side-hill cut some 60 feet wide by 100 feet long has been made about 500 feet west of the west shore of Coyote Lake. An inclined crosscut tunnel, now in 10 feet, is being driven west under this opencut. This tunnel starts on the granitic side of the contact.

The ultra-violet-ray light indicates that scheelite is disseminated across this 60-foot width, and the owners believe that it will exceed 1 percent WO_3. About 300 feet south of this cut, a shaft (now 8 feet deep) is being sunk on a mass of garnet and epidote about 8 feet wide, which shows good values under the light.

The owners have built about 5 miles of road over Coyote Ridge to reach their property. They are now working at the property sinking the shaft and driving the crosscut tunnel.

McGee Creek Mine. A 10-mile road is being built by the federal government to the McGee Creek Mine of Van Loon and Morehardt of Bishop.

Schober & Merrill Group. These four claims are on the west slope of Coyote Ridge on the east side of the South Fork of Bishop Creek, in sec. 22, T. 8 S., R. 31 E., M. D., about 14 miles southwest of Bishop, elevation about 10,500 feet; owners are John and Arthur Schober and Fred Merrill, all of Bishop; the property is leased to El Diablo Mining Company, H. O. Johansen, Bishop.

The rocks exposed in present workings and in the immediate vicinity are all granitic, although limestone outcrops both to the north and south. The deposit now being worked occurs in an intensely fractured zone in the granite. The strike is about N. 20° W. Within this zone there is a network of fractures resulting in mineralization of the mass up to 40 feet in width and probably averaging 25 feet for the 80 feet of length thus far opened. The gangue consists largely of garnet, epidote, and hornblende, and considerable pyrrhotite. The scheelite frequently is found in large crystals, some of them 2 inches or more across.

The ore has been mined in a glory hole about 85 feet long, 25 to 40 feet wide. A crosscut was driven northeast 80 feet to get under the glory hole, and a shaft was sunk 80 feet on 52° inclination from the crosscut. Drift 35 feet north from the crosscut. A drift about the same distance south broke into the south end of the glory hole. Some 3,000 tons of ore, said to average better than 1½ percent WO_3, have been shipped from these workings. The ore is treated in the company's mill on Bishop Creek about 3 miles west of Bishop.

The property is equipped with 360 cu. ft. portable compressor, driven by diesel engine.

Production averages 20 tons per day. Nine men are working.

Tungsten Valley Group. This property, consisting of 16 claims, is in secs. 24 and 25, T. 8 S., R. 31 E., M. D., about 12 miles southwest of Bishop and 3 miles east of the South Fork of Bishop Creek on the West Fork of Coyote Creek, elevation 9,600 to 11,300 feet; the owners are John Udder and A. H. Peterson, of Bishop.

Immediately north of these claims, the east slope of Coyote Ridge appears to be largely limestone, having a westerly dip. The canyon which comes down to the south from Lookout Mountain marks the north end of Coyote Ridge as well as the northern extremity of this limestone outcrop. On the ridge to the north of this gulch only granitic rocks outcrop, but trenching has demonstrated that pendants of limestone from 30 feet to 50 feet thick exist in the granodiorite. At two places on the east side of the gulch, some 600 feet apart, trenching has exposed contacts of the limestone and granitic rock. These contacts strike north, dip 50° W. In the trenches, the contact zone ranges from 8 feet to 15 feet in width. The minerals in this zone are largely garnet and epidote. The 6 feet next to the granitic footwall, which is the east side, is said to run 2 percent WO_3; the other side carries about ½ percent. Farther to the east, contact zones up to 40 and 50 feet in width are reported.

At present 6 men are trenching and sampling the various contacts.

Victory Tungsten Mine. This mine, comprising 4 claims, is on the west side of the South Fork of Bishop Creek, 0.9 miles south of Schober's Resort, in T. 8 S., R. 31 E., M. D., about 16 miles southwest of Bishop; elevation 9000 feet. Owners are Cy Townsend, Mojave; A. H. Lang, Tehachapi; and Oliver Phillips, Schober's Resort, Bishop.

The deposit occurs along a limestone-granite contact; strike is north, dip 57° W. The contact mineral zone, where opened, has a thickness of 30 feet to 40 feet. The limestone is about 300 feet thick and the outcrop has a length of some 700 feet to 800 feet. The predominant minerals in the contact zone are garnet and epidote. Scheelite is disseminated through this rock. The best values are concentrated near the hanging wall or limestone side of the deposit, in a zone 4 feet to 8 feet wide.

On a steep hillside immediately west of the South Fork of Bishop Creek, the deposit has been opened by a side-hill cut some 40 feet long. Here the ore zone mined is from 4 feet to 4½ feet wide. The ore is brought down the hill on a sled and shipped to the Mineral Reduction Company's mill at Benton. The shipments are expected to run 2 percent WO_3.

The property is equipped with portable compressor and one machine. Seven men are working.

KERN COUNTY

Antimony

Top of the World Mine.[1] This mine, comprising 4 claims (one patented) is located on Devil's Creek in sec. 34, T. 30 S., R. 32 E., M. D., 11 miles (4-mile trail) southeast of Caliente, at an elevation of 4000 feet. Owners are Henry G. Hubbard and family, Eagle Rock, California.

The deposit is primary. Scheelite was encountered in a round of holes drilled in a flat incline at the intersection of a fault vein with a contact vein. Auriferous stibnite occurs in kidneys in the weathered contact vein formed by granodiorite and crystalline schist. A large crystalline limestone dike on the property extends northeastward across the township.

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[1] Personal communication from H. G. Hubbard, July 9, 1942.

The mine is developed by 230 feet of old adit (partially caved), an open-cut, a 10-foot winze near portal of old adit, and a 25-foot drift at bottom of winze.

Equipment includes a very small gasoline-driven compressor, jack hammer, 200 feet of steel rail, and a mine dump-car.

Tungsten

B. C. M. Mines. The Summit Line Company property, covering 5700 acres south of Tehachapi, is under lease to R. D. Carse and associates under the name of B. C. M. Mines, address P. O. Box 214, Tehachapi. They have been prospecting for tungsten in the area since October 1941 and have made some small shipments, totaling less than a ton, of selected high-grade scheelite, from approximately sec. 2, T. 11 N., R. 15 W., S. B. There are large bodies of limestone on the property, in contact with granite. Carse reports finding most of the values occurring in the areas where the granite has been altered and shows considerable mineralization. Garnet is abundant on these contacts. He reports finding scheelite over an area some half mile in width and 2 miles long: ''There are extensive systems on the (nearby) Claussenius and Dixon holdings with veins up to six feet in width and considerable rich ore has been found either in or along these veins. The old Pine Tree Mine, which was a gold producer in the early days, is on the Claussenius property, and I have found scheelite either on the dumps or old tunnels in almost every instance.''

Donlevy Tungsten Mines. (Orrell Group.) This group comprises 12 tungsten claims situated in the Green Mountain Mining District, in the Piute Mountains, in sec. 14, T. 29 S., R. 34 E., M. D., 3 miles southeast of Claraville, 12 miles northeast of Loraine P. O., elevation 7000 feet. Owner is Lee Orrell of Weldon, California. The property is under option to Donlevy Development Company, Ross W. Prout, president and manager, 15151 Devonshire Street, San Fernando.

Scheelite occurs in quartz vein, strike northeast in granite. Development consists of trenches and shallow shafts. Tunnel driven northeast on vein 285 feet. Two men are employed.

Dorris and Cuddeback Property. Jesse Cuddeback and W. C. Dorris of Bakersfield, California, are shipping ore to the C. & H. Mill at Weldon, from their property which is some 6 miles east of Weldon.

The deposit is contact-metamorphic, occurring at or near contact of granodiorite and altered limestone; the strike is N. 30° E., dip 65° W. The gangue is tactite. The ore zone averages 5 feet to 6 feet in width. It has been developed by a 60-foot shaft. On the 60-foot level, ore is being extracted from a stope about 65 feet long, 5 feet to 6 feet wide, and 30 feet to 45 feet high. About 1000 tons has been shipped. Data on average values of these shipments were not available.

The property is equipped with a compressor and gasoline hoist. A passable but steep road about a mile long has been built to the property. Four to six men are working.

Good Hope and Little Dick Group.[2] These claims are about 2 miles northeast of Kernville in sec. 23, T. 25 S., R. 33 E., M. D. Owner is C. W. Pascoe, Kernville, California; the property is under lease to George Munsen and H. M. W. Daley, Box 112, Kernville, California.

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[2] See also Partridge, John F., Jr., Tungsten resources of California: California Dept. Nat. Resources, California Jour. Mines and Geology, State Mineralogist's Rept. 37, No. 2 (April), pp. 301-302, 1941.

This is a contact-metamorphic deposit, the scheelite occurring in lenses along the contact of granite and crystalline limestone. The metamorphic rock is a pendant forming the top of the knoll in which the deposits occur. The strike is east. The gangue is garnet, epidote, quartz, and calcite.

The claims have been developed by a tunnel driven south 75 feet. Forty-five feet from the portal, a drift has been driven east about 60 feet.

A small mill formerly on the property has been removed. The present lessees plan to equip and reopen the property when they have provided milling facilities.

Gribble Group. These 6 tungsten claims are about 1½ miles west of Summit Lodge on the west slope of the Greenhorn Mountains, elevation about 5800 feet; the owner is Fred L. Gribble of Bakersfield, California; the property is leased to S. E. Moyer and Frank A. Geisler, also of Bakersfield.

The deposit is contact-metamorphic; the crystalline limestone is on the east, and the granitic rocks on the west. The general course of the contact is N. 30° W. The dip is to the west. The limestone is some 400 feet to 500 feet thick and is traceable for a mile or more.

On the west side of the canyon the contact zone has been traced for some 1500 feet. In the several openings the full width has not been exposed, although in one cut it is shown to be at least 40 feet. The minerals in this zone are largely garnet and epidote; there is some calcite and quartz, and near the hanging wall, considerable hornblende. A persistent quartz vein as much as 6 feet in width also carries scheelite. This whole mass is highly iron-stained where opened on the outcrop.

Development consists of a short tunnel, caved at the time of visit, and opencuts. Samples taken across 40 feet in one of these opencuts are said to average 2.3 percent WO_3; while a cut about 1000 feet northwest is reported to carry 6 percent to 7 percent WO_3.

Two men are working building road to the various openings.

Locarno Mine. The property comprises 97 acres of patented land situated in the SE¼ sec. 21, T. 29 S., R. 34 E., M. D., adjoining the Gwynne Mine on the southwest, in the Green Mountain Mining District, on the southwest slope of the Piute Mountains, 25 miles northeast of Caliente; elevation is 7100 feet; owners are N. V. Franceshi and associates, Bakersfield, California.

Two parallel quartz veins occur in granite, strike N. 30° E., dip 40° SE. Width of veins varies from 12 inches to 2 feet. Development consists of two tunnels driven on the southeast vein. Upper tunnel is driven N. 30° E. on the vein 500 feet. At 230 feet from the portal, there is a raise on the vein to the surface, a distance of 110 feet. Thirty-five feet north of the portal, a winze has been sunk on the vein to a depth of 30 feet. The vein carries gold and tungsten. Scheelite occurs in irregular kidneys along the footwall of the vein.

The lower tunnel is 130 feet in elevation below the upper tunnel and is driven on the vein N. 30° E. for 550 feet. At 410 feet from the portal, a winze has been sunk on the vein to a depth of 90 feet. About 200 feet east of lower tunnel, there is a north-south vein, 2 feet to 4 feet wide, in granite. Opencuts and short tunnels along the strike of this vein have exposed quartz mineralized with scheelite. This is the most important showing of tungsten on the property. The soil along the surface outcrop carries scheelite and is being screened to recover the tungsten. Some 50 sacks of ore have been recovered, reported to carry 50 percent WO_3.

Equipment at lower tunnel consists of Hallett compressor, capacity 120 cu. ft., driven by 15-h. p. Fairbanks-Morse gas engine; blacksmith shop; cars, and air drills. Mill consists of 20-ton ore bin, 8 inch by 10 inch jaw crusher and Gibson mill, capacity 14 tons per 24 hours.

Two men are employed on development.

Lode Mine. This tungsten property south of Weldon is under lease to George Munsen and H. M. W. Daley, Box 112, Kernville, California. They intend to start work immediatey.

The operators are negotiating for the mill at Weldon. Pending the outcome of these negotiations, 8 men are employed. When the milling arrangements have been completed, this force will be very materially increased.

Naja Scheelite Mine. This mine comprises 4 claims situated in the Green Mountain Mining District, on the west slope of the Piute Mountains, in sec. 1, T. 29 S., R. 33 E., M. D., 4 miles northwest of Ranger's Station and 9 miles north of Loraine P. O.; elevation is 8300 feet; owners are Harry Butterbred and L. V. Stover of Weldon, California; the property is under option to Ray Glassbrook, E. R. Sandau, and H. K. Patch, also of Weldon.

A massive tactite outcrop about 200 feet in length and 20 feet to 40 feet in width occurs in granite. The outcrop strikes N. 40° W., dips 70° SW. In places intrusions of granite cut the tactite, striking northeast and dipping 50° NW. The principal scheelite mineralization occurs along these intrusions in a gangue of quartz, epidote, and garnet.

Development consists of shallow trenches and a shaft 20 feet in depth. The indicated ore-shoot is about 50 feet in length and from 3 feet to 6 feet in width. Ten tons of ore extracted from shaft and milled at McKee Brothers mill at Havilah, is reported to have averaged 1.6 percent WO_3.

Equipment consists of 6-h. p. hoist and 110-cu. ft. compressor and truck. Three men are employed on development.

Top of the World Mine. See page 61.

Tungsten Queen Mine. This property, consisting of 2 claims, is 4 miles northwest of Isabella and 2½ miles southwest of Kernville. Owner is Mrs. Minter, Bakersfield, California; it is under lease to George Munsen and H. M. W. Daley, Box 112, Kernville, California.

The deposits occur on the contact of granodiorite and limestone, strike N. 60° W. The extent of the limestone in the immediate vicinity indicates the possibility of the occurrence of many lenses of ore. The gangue consists of garnet, epidote, quartz, and some calcite. The scheelite occurs disseminated in this gangue, frequently being found in large crystals.

The deposit has been developed by opencuts on the northwest side of the canyon and by a tunnel driven to the southeast 68 feet on the southeast side of the canyon.

An inclined tram some 300 feet long has been built to the opencuts. At the foot of the tram is a bin, a track from which also serves the tunnel on the other side of the canyon. A 125-cu. ft. compressor furnishes air.

Zinc

Tejon Ranch (formerly *Cully* and *Hoyes* or *Kelso Mine*). This property is owned by Tejon Ranch Company of Los Angeles. Condor Zinc Company (a limited partnership), R. E. Bering et al., 811 West 7th Street, Los Angeles, has leased 640 acres in T. 9 N., R. 18 W., S. B., near Gorham. The deposit is a replacement in limestone along fractures nearly at right angles to the bedding planes. Two of the three or four fractures found are separated by 4 feet of altered limestone, and the third fracture appears to be about 30 feet to the north; strike about S. 30° W., dip 80° NW., with bedding of limestone dipping 25° S. The veins are iron-stained, and on the outcrop the zinc minerals are carbonates and sulphides. The first two veins, where opened in the middle tunnel are stated to assay 30 percent and 33 percent zinc, respectively, across 5 feet to 6 feet. The lower tunnel has been driven S. 30° W., 60 feet, without reaching the ore. About 150 feet southwest and 60 feet higher, the middle tunnel is in south 40 feet cutting the two veins noted above, and an 8-foot winze shows 6 feet of good-looking ore. The upper tunnel, 250 feet southwest and 100 feet to 125 feet above the middle tunnel, was driven 600 feet S. 48° W., but is caved at 200 feet. At 40 feet from portal, ore 15 feet to 20 feet wide was cut. The present lessees have built about 3 miles of mountain road to the workings.

MONO COUNTY

Tungsten

Sierra Vista Mine. Aaron J. Smith and Frank S. Jackson, under the name of Smith & Jackson, 707 Bixby Road, Long Beach, California, have a lease on the Sierra Vista Mine and mill in the Chicago Mining District, Mono County.

It is their intention to add a table and make some minor changes in the mill to make it suitable for the treatment of scheelite ores. They report that they have discovered scheelite in the workings of the Sierra Vista Mine and that they can secure ore from other properties in this vicinity, notably near the Black Rock Mine.

RIVERSIDE COUNTY

Antimony

Mountain Group. This group of four claims, owned by J. Erenreicht, Corona, California, is under lease to R. A. Mattey, 3721 Westwood Boulevard, Los Angeles. Exploration work consists of a trench and short tunnel about 50 feet in length. Scattered over the area is considerable heavy float. The mineralized area is probably 200 feet across and 1000 feet in length. From the trench, Mattey shipped 719 pounds of ore to the Harshaw Chemical Company, El Segundo, California, which ran 38.7 percent antimony. Cut samples made at intervals in the opencut assayed 10 percent to 28 percent antimony. It appears that considerable ore could be exposed that could be sorted to 40 percent antimony.

The deposit is in the Cleveland National Forest, and in order to open and develop it, a road will have to be built from the Tillitson Ranch up Mabey Canyon, a distance of three-quarters of a mile.

Copper and Gold

Alice Group. These mines are in the Bendigo District. Freidric Frei, 5762 Tuxedo Terrace, Los Angeles, is lessee. This ore carries principally gold, and about 3 percent copper. Shipments to the Magma Company's smelter at Superior, Arizona, as well as to Hayden, indicate a high silica content. Frei has erected a 50-ton mill on the property and will be ready to operate when a well has been drilled near the property for water.

SAN BERNARDINO COUNTY

Copper and Gold

Vontrigger Copper Mine (formery known as *California Gold and Copper Mines*). This property is being reopened by H. C. Mills of 718 South Union Street, Los Angeles, who has it under lease. It consists of 9 patented claims located 10 miles north of Goffs, a station on the Santa Fe Railroad. Elevation is 3700 feet. The mine was discovered in 1890, worked in 1908, from 1912 to 1917, and from 1926 to 1929. During 1926-1928, seventy cars of ore carrying 5 percent copper were shipped. Total production for 1928-1929 is reported as $25,000.

There are two veins on contact of granite, quartz-diorite and gabbro. The ore is chalcopyrite associated with pyrite, carrying 4 percent to 7 percent copper and $1 to $2 in gold. Developed by 2 shafts with a total of 5000 feet of underground workings.

The present lessee is installing hoisting equipment, repairing ore bins and retimbering a drift on the 82-foot level of the Medberry shaft. He plans to ship copper ore to the smelter at Garfield, Utah.

Iron

Bessemer and Western Iron Mines (formerly *Iron Mountain Mine*). Owners of this property are California Iron Company and Union Oil Company, Los Angeles; under lease to California Iron and Mine Company, 311 California Street, San Francisco, Harry L. Brown, president; Allison Jones, secretary; Edward Morris, consulting engineer and manager; W. L. Broch, superintendent. This group is in Lava Bed Mining District, in secs. 27 and 28, T. 6 N., R. 4 E., S. B., 30 miles northeast of Lucerne, and 18 miles south of Newberry station on the railroad; elevation 3000 feet to 3880 feet. It is on the southern slope of Iron Mountain Ridge in the Newberry Range. Holdings comprise 7 patented claims (140 acres) in the Bessemer Group and 26 unpatented (520 acres) in the Western Iron Group. Estimated tonnage, 10,000,000. It is a replacement deposit, with two massive veins of hematite and magnetite showing on a contact of dolomite and diorite in the Bessemer claims. Analysis shows: Fe_2O_3, 60 percent; SiO_2, 5.5 percent; sulphur, 0.06 percent; phosphorus, 0.045 percent. The two veins show from 30 to 40 feet, and 30 feet to 50 feet, respectively, in width, proved for a length of 3000 feet, strike N. 20° E., dip 30° NW. Maximum depth thus far in development is 80 feet through shafts of 50 feet to 60 feet and a 60-foot tunnel.

About 2 miles south of the Bessemer Group deposit, on Western Iron Claims No. 22, 23, 25, 26, 27 are iron ore outcrops, and a large amount of float ore on the surface. On No. 26 the outcrop is 20 feet in length by 10 feet in width; on No. 28, the outcrop is 600 feet in length by 150 feet in width; strike is N. 60° W.; development includes several shafts 10 feet in depth.

Magnesite

Ball Magnesite Mine (formerly *Kramer Hills Magnesite*). This property is owned by O. H. Ball, 2024 West 62nd Street, Los Angeles, and operated by Red Seal Chemical Company, O. H. Ball, president. It is in Kramer Hills Mining District, in secs. 10, 11, 14, and 15, T. 9 N., R. 6 W., S. B., 9 miles southeast of Kramer station on the Santa Fe railroad, and 20 miles north of Adelanto; elevation 3000 feet. Water supply is obtained from wells at Kramer. There are 10 claims covering an area of 200 acres, with a length of 6000 feet on the lode. The magnesite is a sedimentary deposit between dolomite and gneissoid granite and schist. Analyses show: MgO, 43.7 percent; CO_2, 49.80 percent; SiO_2, 3.70 percent; Fe_2O_3 and Al_2O_3, 0.92 percent; CaO, 1.73 percent. Strike is east, dip 50° south, average width 300 feet. Development consists of a series of trenches and shallow shafts. A trench cut across for a distance of 164 feet to depth of 6 feet to 8 feet south to the dolomite footwall exposes 50 feet of magnesite, also beds 6 feet to 8 feet in thickness intermixed with dolomitic clay and bentonite shales. Since April 1941, four additional claims have been located and a number of trenches made with a bulldozer, increasing the visible width of this deposit; also additional trenches and shafts have been made, which show a large tonnage of magnesite with low silica content. The company has an option on Cajon Lime Plant, near Cajon on the Santa Fe railroad, for calcining the magnesite.

Manganese

Black Tiger Claim. This claim is owned by A. R. Orchard, 215 East Palmer Avenue, Glendale, California. This claim, located in 1939, is 15 miles north of Parker Dam, on the south and west bank of Colorado River, 23 miles by a fair road from Earp. There are a number of narrow streaks from 1 inch to 5 feet of psilomelane and pyrolusite, associated with basalt, conglomerate, and sandstone, and some barite disseminated through the mass. One exposure 5 feet wide by 60 feet long looks like commercial ore. Strike is N. 40° W., dip apparently 45° SW. The entire low ridge for several hundred feet in length may prove to be low-grade ore. The U. S. Bureau of Mines has done some exploratory work here.

Tungsten

Sagamore Mine (formerly *New York*). This mine comprises 8 patented claims and 24 held by location; it is in San Bernardino

County, in the New York Mountains, in secs. 32 and 33, T. 14 N., R. 16 E., S. B., about 10 miles southeast of Ivanpah; elevation is 6,000 feet; owners are L. D. Godshall and associate, 722 South Oxford Avenue, Los Angeles. The property is under lease and option to California Sulphur Company, J. C. Baldwin, president, 1427 East 4th Street, Los Angeles. Francis W. Gage is general manager, in charge of operations, on the property. This is an old property worked many years ago, and patented in 1905.

Crystalline limestone, quartzite, rhyolite, and granitic rocks, all outcrop on the property. At both the east and west ends of the patented property, there is a large body of limestone. These two limestone masses are separated by 5000 feet of the rocks mentioned above. Four roughly parallel veins are known to exist in these rocks. They strike a little north of west and dip steeply (about 80°) to the north. The principal vein is the second most northerly one. It is a fault fissure filled with quartz and traverses all of the rocks of the area. Where opened, in most instances, it appears to be on the contact of limestone or quartzite, with rhyolite or the granitic rock. This massive vein, from 4 feet to 15 feet or more in width, in many places stands above the surrounding rocks 25 or 30 feet. In the ore-shoots, nine of which are said to have been found, the valuable minerals are sulphides of copper, lead, and zinc (carrying about one ounce of silver to each percent of lead), and huebnerite. While all of these minerals are found in the same shoot, the richer concentrations of the tungsten minerals appear to be separate from those of the lead-silver, copper, and zinc. At least in one place, along the strike, the tungsten minerals appear to decrease as the other metallic ones increase. If this proves to be true, the treatment of the complex ore would be simplified. The ore shoots average over 100 feet in length and are from 4 feet to 15 feet wide.

Principal development consists of a tunnel driven west 1000 feet on the vein at an elevation of about 6500 feet. The west face of the tunnel is about 400 feet east of the large body of limestone mentioned above. This tunnel, which was caved, has now been cleaned out and retimbered for 570 feet, where it intersects an old shaft from the surface, some 200 feet above. Another old shaft is approximately 200 feet from the portal of the lower tunnel. The upper tunnel, driven west 600 feet, is about 100 feet above the lower tunnel. Half a mile or more to the east of these workings, there is a glory hole 120 feet long, 4 feet to 10 feet wide, and 30 feet in depth. In places on the north or hanging-wall side of this cut, 4 or 5 feet of quartz, which appear to be high-grade tungsten ore, still remain.

The present operators have cleaned out 570 feet of the lower tunnel and built 2 miles of road from the camp to the tunnel workings. Eight men are working.[3]

Victory Tungsten Group. These 8 claims are in sec. 6 (?), T. 5 N., R. 17 E., S. B., in San Bernardino County, in the Old Woman

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[3] Partridge, J. F., Jr., Tungsten Resources of California: California Dept. Nat. Resources, California Jour. Mines and Geology, State Mineralogist's Rept. 37, no. 2 (April), p. 308, 1941.

Cloudman, H. C., Huguenin, Emile, and Merrill, F. J. H., San Bernardino County: California State Min. Bur., State Mineralogist's Rept. 15, p. 790, 1919.

Aubury, Lewis E., The copper resources of California State Min. Bur., Bull. 50, pp. 331-333, 1908.

Mountains, about 12 miles southeast of Danby; elevation 4300 feet; owners are L. J. Rouchleau and Maude M. Richardson, 2700 Budlong Avenue, Los Angeles.

These claims are on the south side of Carbonate Gulch. The country rock is granitic and there are many diorite dikes. These dikes show two sets of fractures, trending northwest and northeast respectively. These fractures are filled with quartz forming numerous veinlets. The northwest-trending veinlets (from $\frac{1}{8}$-inch to $\frac{3}{4}$-inch wide) carry scheelite. The other fractures, as a rule, do not. While this condition appears to be general on this hillside, sufficient work to determine the size of any particular deposit has not been done. In places, the fracture planes are covered with scheelite and the fractured zone is 15 feet or more in width. Considerable trenching will have to be done before any estimate of the width and length of these zones can be made.

About 2 miles up the canyon to the east, adjoining the Long Shot Mine on the east, there are several outcrops of dolomite. The contact of this rock with the granite is marked by deposits of epidote and garnet as much as 8 feet in width. This material carries some scheelite and thorough prospecting may disclose a considerable tonnage of commercial ore.

The owners are making trails and prospecting the ground with the ultra-violet light.

Zinc

Mohawk Zinc Mine. This mine is owned by L. Tomlinson, Big Bear Lake P. O., and is under lease to Universal Industries, Inc., W. Scott Hall, president and manager, Max L. Meyer, secretary, 8366 Blackburn Avenue, Los Angeles. It is in Black Hawk Mining District, in secs. 22 and 23, T. 3 N., R. 1 E., S. B., 6 miles northeast of Big Bear Lake P. O., elevation 6500 feet to 6800 feet, 1 mile south of Burnt Flat on the north slope of the San Bernardino Mountains; it includes 10 claims, 200 acres. The deposit is in an iron gossan on contact between granite and dolomitic limestone; it carries pyrite, chalcopyrite, sphalerite, and galena. Vein averages 6 feet in width, strikes N. 34° E., dips 75° E., and has a proved 400-foot length on surface. Lower tunnel has been driven N. 35° W. for 133 feet as crosscut then southwest 120 feet on vein; the upper tunnel, 300 feet above, has been driven 180 feet. Development shows 9 feet of sulphide ore in face of upper tunnel, and 8 feet in face of lower tunnel. It is stated to assay zinc, 18 percent; lead, 4.5 percent; iron, 30 percent. Equipment includes 280-cu. ft. portable Ingersoll-Rand compressor, jack hammers, blacksmith shop, and truck.

SAN DIEGO COUNTY

Tungsten

Sundown Tungsten Mine. This mine comprises 2 claims. It is on the summit of Laguna Mountain, in sec. 28, T. 15 S., R. 4 E., S. B., 6 miles west of Laguna P. O.; the elevation is about 6250 feet; owners are B. J. Chamberlain, Warner Hot Springs, California, and Eugene Rice, Winchester, California; the property is under lease and option to N. Sutherland and B. L. Miller, 1902 West 64 Street, Los Angeles.

At the time this property was visited (January 22, 1942) the surface was covered with snow and the shaft was filled with water. The information obtained at that time was from one of the workmen. It appears now, from information given by present lessees, that the deposit consists of a body of rather coarse-grained tactite which rests on a granitic rock with only a slight dip to the north. It is reported that the deposit is exposed on the surface for a distance of 60 feet to 70 feet in both easterly and northerly directions, and is shown to be 16 feet to 20 feet thick, by the underground workings. Scheelite is disseminated through the tactite in quantities said to exceed, on the average, 1 percent WO_3.

The property has been developed by a shaft sunk 65 feet on 70° inclination to the north. Levels are reported at 20 feet and 65 feet. On the 20-foot level, drift east 30 feet with 20-foot crosscut north from face of the drift. This level was connected by a raise to bottom of a glory hole which is about 30 feet long, 6 feet to 8 feet wide, and 8 feet to 10 feet deep. All of the workings are said to be in ore. On the 65-foot level, a drift 20 feet west is not in ore. Water for the mill is pumped from this level.

Present lessees say that the mill has been changed and now consists of jaw crusher, elevator to ball mill to hydraulic classifier, to 2 sand and one slime table.

Three men have been employed setting up the mill.

SACRAMENTO FIELD DISTRICT

CURRENT NOTES ON ACTIVITY IN THE STRATEGIC MINERALS, SACRAMENTO FIELD DISTRICT

By Charles V. Averill *

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AMADOR COUNTY

Copper

Interest is being shown in the old copper mines of Amador County, and development work, including diamond drilling, will probably soon be under way.

Manganese

Stacy Lease. Dr. Joseph T. Stacy, Pine Grove, or Lenhart Hotel, Sacramento, is operating a manganese property in sec. 24, T. 7 N., R. 12 E., M. D. Some ore has been shipped to Metals Reserve stockpile at Auburn, and development work is proceeding. Reconstruction Finance Corporation has granted a preliminary development loan.

BUTTE COUNTY

Chromite

Parks Property. This property, in sec. 7, T. 21 N., R. 4 E., M. D., has been leased to A. Stevenson, Sacramento, T. W. S. Clark, C. M. McNallen, and Irwin H. Reimers. Several carloads of chrome ore have been shipped to Metals Reserve stockpile at Sacramento. The first carload ran 39.61 percent chromic oxide and brought $38.70 per long ton.

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* District Mining Engineer, Sacramento Field District, California State Division of Mines. Manuscript submitted for publication December 31, 1942.

CALAVERAS COUNTY

Copper

Keystone Mine. The Keystone Copper Company, a partnership of Charles W. Stewart, Claude E. Nuss, 410 Thorn Street, Fresno, and H. E. Bush, F. W. H. Beauchamp, Copperopolis, has reopened the Keystone mine at Copperopolis, secs. 33, 34, T. 2 N., R. 12 E., M. D. A nearby mill is being operated, and concentrate is being shipped to a smelter.

Napoleon Mine. This property, in sec. 23, T. 1 N., R. 11 E., M. D., is being reopened by The Mountain Copper Company, Ltd., 351 California Street, San Francisco. The mine is believed to contain zinc as well as copper.

EL DORADO COUNTY

Chromite

Pilliken Mine. This mine, located in secs. 21, 22, 28, T. 11 N., R. 8 E., M. D., was operated until the fall of 1942 by Rustless Mining Corporation, Sacramento. The lease was then relinquished to U. S. Chrome Mines. Under Rustless Mining Corporation, the mill was operated to treat about 135 tons of chrome ore per day for the production of concentrate by gravity methods—jigs and Deister and Wilfley tables.

Swortfiguer Mine (formerly *Expansion*). This mine is owned by George B. Swortfiguer, Rt. 5, Box 8295, Sacramento. It is on an agricultural patent of 500 acres, in secs. 17, 18, T. 10 N., R. 10 E., M. D., near Shingle Springs. The property is stated to have produced 80 tons of chrome ore during 1914-1918, and some superficial prospecting has been done recently by Jack Pine who lives on the property. A cut 14 feet long, 2 feet wide and 1 foot deep exposes a small amount of chromite, and a small dump shows milling-grade material. Similar ore outcrops 100 feet to the southeast.

Volo Mining Company. This company operated a mill for the production of concentrate during the last half of 1942 in sec. 22, T. 10 N., R. 10 E., M. D. Ore was hauled in trucks from several deposits in the vicinity, one of which is in sec. 14, T. 8 N., R. 9 E., M. D., and the section adjoining on the north. F. V. Phillips, Box 586, Placerville, was in charge.

Wilson Property. Russell Wilson, Garden Valley, has been mining chrome ore in sec. 23, T. 12 N., R. 10 E., M. D., and vicinity. Some shipping ore has been produced, and some ore of milling grade has been treated at the Big Sandy mill at Kelsey.

Zinc

Big Buzzard Mine (Darrington). This mine, in sec. 29, T. 11 N.. R. 8 E., M. D., 12 miles east of Folsom, is leased by Goodwin M. Trent of Auburn. A little dump-ore containing zinc has been shipped. The ore contains copper, lead, gold, and silver in addition to the zinc. Plans are said to call for re-opening the mine.

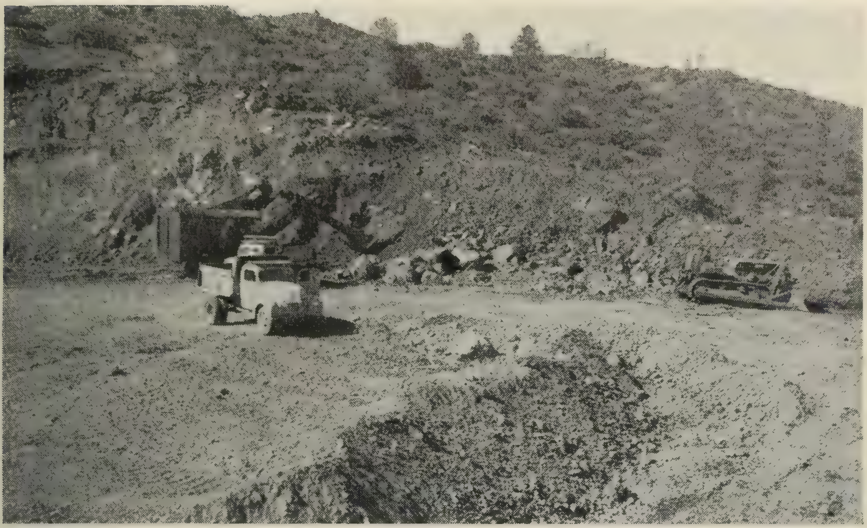

FIG. 1. Mining chrome ore, Glenn County, by Rustless Mining Corporation, Sacramento

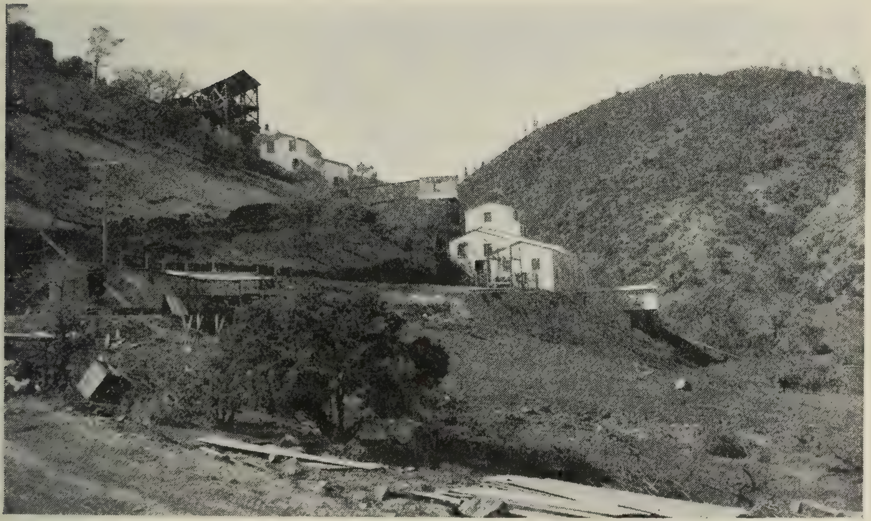

FIG. 2. New mill for chrome ore, Glenn County, operated by Rustless Mining Corporation, Sacramento

GLENN COUNTY

Chromite

Rustless Mining Corporation, 1014 Eighth Street, Sacramento, is operating a property in Glenn County for the production of chromite concentrate. The exact location of the property is omitted at the request of the company. A body of ore large enough to justify the construction of a mill with a capacity of 200 tons per day was developed with the help of the U. S. Geological Survey and U. S. Bureau of Mines. The mill has been producing concentrate steadily since the end of February, 1942. Marcy ball mills, 4 feet by 5 feet, open end, (Bishop type) are used for grinding, and concentrate is made in jigs and on Wilfley tables. C. E. Osborne is superintendent, and C. M. Marquardt is assistant superintendent. Open-pit methods are used in mining, and a 1-mile cable-tram connects the mine with the mill.

NEVADA COUNTY

Gold

Lava Cap Gold Mining Corporation (Otto E. Schiffner, General Manager, Nevada City) continues to operate because the concentrate produced is valuable for flux at the Selby lead smelter.[1] (July 1, closed).

Magnesite

Promise to Pay Group (formerly *Gold Lead Mine*). These two claims located in secs. 25, 36, T. 18 N., R. 10 E., M. D., 25 miles from Grass Valley, are owned by George Cacic, Nevada City, and are under option to Investment Corporation, Frank Richards, 409 Ochsner Building, Sacramento. In a line 75 feet long on the surface, striking S. 40° E. are two or three outcrops of magnesite in serpentine, which are 2 to 4 feet in width. The direction and angle of dip cannot be seen, though possibly the full width is not exposed. To the southeast (S. 67° E.) about 500 feet is another outcrop, but not along the same line of strike; there are two other outcrops between these mineralized zones.

Gold Lead is an old drift mine and the bedrock tunnel is in serpentine. From the portal, this tunnel runs N. 14° E. about 300 feet. For a distance of 100 feet magnesite is seen here and there in widths of about a foot and in kidneys; the strike appears to be about at right-angles to the tunnel, and dip nearly vertical. One 6-inch stringer strikes N. 33° W. and dips 58° N.E. The exposure in the tunnel is roughly 200 feet to the northwest of the main outcrop, and roughly 100 feet below the surface, but some surveying is needed to determine just what these distances are and whether the exposure in the tunnel is the same lens as the surface outcrop.

Manganese

Mangachrome Company, a partnership of Neville and Slater, Box 448, Auburn, has been producing manganese ore from the Dugan ranch and other adjoining land in sec. 17, T. 14 N., R. 8 E., M. D., at the junction of the Lime Kiln and Wolf roads. Several hundred tons of shipping ore has been delivered at Metals Reserve stockpile in Auburn. Plans call for the construction of a washing-plant to recover concentrate from lower grades of ore.

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[1] For details of the operation of this and other mines in Nevada County, see Chandler, John W., Mining methods and costs of the Lava Cap Gold Mining Corporation, Nevada City, California, pp. 409-424; and Logan, C. A., Mineral resources of Nevada County, pp. 374-436: California Dept. Nat. Resources, California Jour. Mines and Geology, State Mineralogist's Rept. 37, no. 3 (July), 1941.

PLACER COUNTY

Chromite

Beat Chrome Claim. This claim is in sec. 6, T. 15 N., R. 11 E., M. D., and is held by Dan Sullivan of Casa Loma. Sullivan works the claim alone and produces high-grade chrome ore from lenses for shipment.

Embree Group. This group, in secs. 20, 29, T. 14 N., R. 11 E., M. D., is held by James O. Embree, Box 58, Auburn. Embree has been shipping chrome ore to Metals Reserve stockpile at Auburn.

Fitzgerald and Russell Leases. In sec. 32, T. 15 N., R. 11 E., M. D., and secs. 5, 6, 9, T. 14 N., R. 11 E., M. D., 1240 acres of land are held by Ralph Fitzgerald and Roscoe Russell, 582 Market Street, San Francisco. Development of chrome ore is proceeding with funds derived from a preliminary development loan granted by Reconstruction Finance Corporation. Part of this land is leased from Southern Pacific Land Company, and this same tract was leased by George A. Muller and M. T. Mathews in 1941. They produced and shipped one or two carloads of chrome ore.

Geisendorfer Lease. C. A. Geisendorfer, Colfax, has recently worked land held by Southern Pacific Land Company, San Francisco, in sec. 7, T. 15 N., R. 11 E., M. D., and has produced some chrome ore for shipment. The lease is in the name of H. A. Geisendorfer, 1931 Napa Avenue, Berkeley.

Horseshoe Claim. This claim, in sec. 30, T. 15 N., R. 11 E., M. D., is held by E. W. Drone and two brothers, Forest Hill. A lens of chrome ore was discovered here in 1941, and shipments were made to Metals Reserve stockpile at Auburn under a lease held by Braden and Dart. A little concentrate was produced in sluices with riffles as the result of hydraulic operations with a 2-inch nozzle.

Victory Chrome. Charles Hopper Brown and others, Auburn, hold in partnership, 1660 acres of leases in the Forest Hill District, secs. 19, 20, 28, 29, T. 15 N., R. 11 E., M. D. In the spring of 1942, machinery was installed for producing chrome concentrates by gravity methods. This consisted of a trommel punched with $\frac{1}{2}$-inch holes; oversize went to an 18-inch belt for hand-sorting. Undersize was treated in jigs. This outfit was operated for a while during the summer of 1942 on ore that was mined from the surface with a small power shovel. The property was idle during the latter part of 1942 because of a shortage of water.

Washout Claim. George Ford and John Lower, both of Forest Hill, operated this claim in sec. 30, T. 14 N., R. 11 E., M. D., Forest Hill District, in 1941 and 1942. Several hundred tons of chrome ore of a very good grade have been shipped. This ore runs about 50 percent chromic oxide and has a chromium-iron ratio of more than 2½ to 1.

SIERRA COUNTY

Chromite

Milton Chrome Claim. This property in sec. 4 (?), T. 19 N., R. 12 E., M. D., claimed by R. C. Zaring, Downieville, produced chrome ore in 1941. Mrs. Marie E. Phelan, 2226 Capitol Avenue, Sacramento, has stated to the writer that she holds title to this land.

Oxford Quartz Mining Company. This company (A. J. Just, secretary, Downieville) holds a large acreage of land in secs. 22, 23, 26, 27, T. 20 N. R. 10 E., M. D. The property produced chrome ore during the war of 1914-18 and has recently been reopened for further development by C. L. Best, Caterpillar Tractor Company, San Leandro, with L. L. Huelsdonk, Downieville, in charge. Plans call for milling chrome ore in a modern mill on the property.[2]

TUOLUMNE COUNTY

Chromite

Marsh's Flat Chrome Group. This group of claims in secs. 30, 31, T. 1 S., R. 15 E., M. D., is held by John L. Witney, Inc., Jamestown, California. Several thousand tons of a milling grade of chrome ore are stated to have been developed here by J. V. Wulff, manager. Recent reports indicate that a mill is to be built.

McCormick Property. Recently this property, in sec. 2, T. 1 S., R. 13 E., M. D., has produced at least a carload of chrome ore under a lease held by Carl Howe, Columbia. The ore came from a lens which has been developed to a depth of 185 feet.

Stuart and Everhart. This partnership of J. F. Stuart, 1201 W. Floral Street, Stockton, and G. E. Everhart, Box 210, Jamestown, holds leases in secs. 25, 26, T. 1 N., R. 13 E., M. D., at Peoria Flat. They have recently produced some chromite concentrate with a stamp mill and Wilfley tables. The ore fed to the mill is about 23 percent chromic oxide.

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[2] See also Averill, Charles V., Mines and mineral resources of Sierra County: California Dept. Nat. Resources, California Jour. Mines and Geology, State Mineralogist's Rept. 38, No. 1 (January) p. 35, 1942.

REDDING FIELD DISTRICT

CURRENT NOTES ON ACTIVITY IN THE STRATEGIC MINERALS, REDDING FIELD DISTRICT

By J. C. O'Brien *

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DEL NORTE COUNTY

Chromite

Big Dipper Mine. Sec. 7, T. 16 N., R. 3 E., H. Charles Bennett, Syms Camp, and James K. Remsen, Grants Pass, had 4 men employed. Shipments were made to the stockpile at Grants Pass, Oregon, 86 miles by road and highway.

Bonanza Claim. Sec. 21, T. 18 N., R. 2 E., H. Leased and operated by Clifford Johnson and Delbert O'Brien, of O'Brien, Oregon. Small lots of ore were shipped to Grants Pass.

Camp 8. Sec. 19, T. 16 N., R. 3 E., H. Charles Bennett and James K. Remsen had 5 men employed mining and sorting ore which was shipped to Grants Pass.

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* District Mining Engineer, Redding Field District, California State Division of Mines.

High Dome Claim. Sec. 19, T. 18 N., R. 3 E., H. Edward Cook, owner. Leased to Charles Bennett and James K. Remsen. Three men were employed in July 1942 mining and shipping ore to Grants Pass.

High Plateau Mine. Sec. 22, T. 18 N., R. 2 E., H. Owned and operated by Eugene Brown of O'Brien, Oregon. This property had over 4000 tons of high-grade chrome ore developed in June 1942 and was the largest contributor to the stockpile at Grants Pass. Ore had to be hauled over 26 miles of rough, winding mountain roads to O'Brien, Oregon, and 40 miles from there to Grants Pass. Nine men were employed.

Muzzle Loader Claim. Sec. 4, T. 15 N., R. 3 E., H. Owned by William and Robert Stevens and leased to Charles Bennett and James K. Remsen. Three men were employed and about 60 tons of chrome ore was stockpiled awaiting construction of a road.

French Hill and Mountain View Mines. Tyson Chrome Mines, Ltd., B. C. Mickle, manager, operated the French Hill mine in secs. 5-6, T. 16 N., R. 2 E., H., and the Mountain View mine in sec. 35, T. 18 N., R. 1 E., H. Shipments were made to Grants Pass, Oregon.

U. S. Vanadium Corporation, San Francisco, California, established a stockpile at Crescent City and purchased chrome ore in small lots in the fall of 1941 and spring of 1942 before the Metals Reserve Corporation stockpiles were established at Grants Pass, Yreka, and Anderson. They made it possible for many small operators to develop their deposits by furnishing a convenient market where they could sell their ore. The ore was hauled to the Metals Reserve stockpiles after they were established.

Small lots of chrome ore were delivered at Grants Pass from various California deposits by C. H. McClendon, W. E. and E. R. Gilmore, Syms Camp; Crescent City Mining Co., Medford, Oregon; and Charles A. Gillis, Smith River, California.

Quicksilver

H. C. Wilmot, Southerland, Oregon, is developing a quicksilver deposit in sec. 18, T. 18 N., R. 3 E., H. Native quicksilver and cinnabar occur in vugs and seams in a gray andesitic rock.

HUMBOLDT COUNTY

Chromite

Mosquito Lake Chrome Mine. Sec. 11, T. 11 N., R. 4 E., H. Owned and operated by Llewellyn O. Wilder and son. Shipping to Yreka stockpile.

Rivers Chrome Mine. Sec. 13, T. 11 N., R. 4 E., H. Operated by Mrs. Dorothea Reddy Moroney of Hamburg. This property made the first delivery of ore to the stockpile at Yreka and has been the largest contributor in spite of a 150-mile haul over difficult roads. Five men are employed.

Woodhouse Chrome Mine. Sec. 24, T. 10 N., R. 5 E., H. A road was built to this deposit by I. E. Bliking and deliveries were made to Yreka 145 miles distant.

Copper

Hoopa Indian Reservation. A promising copper-zinc prospect in sec. 2, T. 8 N., R. 4 E., H. is being prospected by cuts and trenches by A. W. Scott of Happy Camp.

Red Cap (Sky Chief) Mine. Sec. 29, T. 10 N., R. 6 E., H. This mine was purchased by A. M. Johnson of Los Angeles. A prospect shaft and crosscuts are being driven under the supervision of George M. Robinson of Orleans. Three men employed.

LASSEN COUNTY

Iron

George Maxwell, Meadow Valley, showed the writer a specimen of hematite and an assay certificate reporting 62.8 percent iron. He said it came from a deposit 15 miles east of Westwood and 5 miles south of Susanville. He reported an outcrop 40 feet wide and 250 feet long, showing float for a mile toward the south, where there is another outcrop 15 feet wide.

PLUMAS COUNTY

Chromite

Meadow Valley Deposits. W. J. Gear, Quincy, chairman of the Quincy Mining Association, reported five chrome claims, located on both sides of Meadow Valley, that have from 5 to 18 tons of chrome ore carrying 33 to 44 percent chrome on their dumps. These deposits will be worked when a depot is opened at Quincy. W. R. Monroe, Coalinga, is said to have an option on 200 acres of patented ground showing chrome float. This property will be prospected with a bulldozer.

Peerless Development Company Property. In August 1942, this Company (333 Kearny Street, San Francisco, B. K. Melville, Greenville, president) had about 40 tons of chrome ore on its property in sec. 1, T. 26 N., R. 8 E., M. D. which was mined during 1917-1918. This ore was mined from shallow surface lenses in serpentine, but the pits have since been filled. Other dumps near caved pits in serpentine in sec. 36, T. 26 N., R. 8 E., M. D., hold some 30 tons of ore, mined during World War I. The ground is said to be leased to George Neseath, who operated the Gold Stripes mine nearby; but no recent work has been done.

Spillover Placer and Quartz Claims. Albert Ziebar of Greenville operates these claims in sec. 6, T. 26 N., R. 9 E., M. D.; he has about half a ton of chrome ore which he has picked up as float while searching for its source in the serpentine on his claim. He has not found it in place yet.

White Pine Group. Secs. 8, 9, 16, 17, T. 23 N., R. 9 E., M. D. Several lenses have been exposed in bulldozer cuts on this property operated by E. R. Patterson of Meadow Valley. Shipping to the stockpile at Quincy.

Small lots of ore were delivered to the stockpile by Henry Fuller, George Maxwell, Robert Ridley, Edward Smith, and S. Weeks.

Copper

Walker Mining Company at Walkermine suspended operations in October 1941 due to increased cost of operation. A production of 7,248,128 pounds of copper, 166,581 ounces of silver and 10,938 ounces of gold was reported for 1941.

Consolidated Gold and Metals Co., J. R. Walker, Salt Lake City, president, is developing a group of copper claims north of the Walker mine.

Manganese

Mount Hough Manganese Mine. This mine consists of three claims in sec. 8, T. 25 N., R. 10 E., M. D., which are a relocation of the Crystal Lake manganese group.[1] It is now owned by George Holloway, Quincy, and leased to John A. Foley and J. H. Lashbaugh of San Francisco. One car shipped to Salt Lake was reported to assay 52.4 percent and to have been ''High Grade A.'' New development consists of a tunnel driven S. 55° E. for 80 feet, and a raise 12 feeet; it is necessary to raise 20 feet more to reach the old workings. The country rock is a gray and red schist striking southeast. The vein is about 6½ feet wide, the hanging wall being red jasper, the footwall schist. There is some good looking manganese showing, and the white quartz which runs in seams through it seems to part from it readily. The ore will have to be sorted for shipping. The deposit is 13½ miles from Quincy and the last 5 miles of road should be improved.

Rock Creek and Red Mountain Deposits. W. J. Gear of Quincy has an interest in five manganese claims on Rock Creek. Development is by a trench 200 feet long, 12 feet wide, and 16 feet deep. Mr. Gear states that the manganese is associated with red jasper, and is high in silica. Other deposits of chrome and manganese are said to occur on Red Mountain, but are idle at present.

Sunset Mining Claims. The Sunset claims No. 1 and No. 2 are located about half way between Seneca and Wolf Creeks on the summit in the Seneca mining district. They cover large outcrops of manganese too high in quartz and red jasper to be mined under present specifications. The claims were located in 1930 and the only development work is a pit about 15 feet deep. No commercial ore shows.

Western Manganese Mine. O. H. Griggs and associates of Los Angeles are operating the Western manganese mine near Crescent Mills, sec. 26, T. 26 N., R. 9 E., M. D. They have reopened portions of five old tunnels and have shipped about 500 tons of ore said to average 41 to 43 percent manganese and 21 to 26 percent silica. An R. F. C. loan has been requested, to finance the reopening of two caved tunnels. One of these has already been reopened for about 60 feet, and it is estimated that 85 feet more must be driven to reach a point beneath a winze showing ore in the bottom, and a hole from the old level about 40 feet above. No stoping above the lower tunnel is known. The vein is from 30 inches to 8 feet wide, where it can be seen, and strikes N. 35° W. Its hanging wall is a red jasper spotted rock. It is probable that there is a considerable tonnage of low grade "B" ore present; this could be determined by detailed mapping.

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[1] See Averill, Chas. Volney, Mineral resources of Plumas County: California Jour. Mines and Geology, vol. 33, no. 2, April, p. 143, 1937.

Wild Rose Placer Claim. There is a 4½-foot vein of manganese striking S. 70° W. and dipping 70° S. on the Wild Rose placer claim in sec. 8, T. 26 N., R. 9 E., M. D., which is owned by Charles De Velter of Greenville. Both the hanging and the footwall are gray schist. The top half of the vein is largely quartz and red jasper but the lower 2½ feet along the footwall appears to be a good grade of ore. The vein is about 300 feet long, as indicated by crosscut tunnels. No work is being done on this deposit at present and there has been no production.

Tungsten

Grizzly Tungsten No. 1. This is a new prospect in sec. 11, T. 23 N., R. 5 E., M. D., consisting of one claim located March 11, 1942 by C. B. Goodrich. Leased with option to J. P. Branley, Greenville. The claim is on the Feather River highway close to the Butte County line.

Country rock is a gray to black hornblende schist which rises steeply from the highway. A granitic rock, probably granodiorite, invades the schist in many places and dikes of syenite are common.

The portal of the discovery adit is about 150 feet above the highway and is run on the contact of the schist for 13 feet. The face and walls are metamorphic in character and show actinolite, fine to coarse garnets, and quartz. Specks of tan-colored scheelite occur in the metamorphosed rocks and in seams in the schist. No assays have been made as yet to determine the grade of the ore. There are other metamorphosed zones showing garnet and wide bands of crystalline calcite which may also carry scheelite. Lack of dump room will handicap development.

SHASTA COUNTY

Asbestos

Stock Asbestos Mine. Thirteen claims and patented land in secs. 1, 2, 3, 4, T. 37 N., R. 5 W. and secs. 33, 34, T. 38 N., R. 5 W., M. D., are leased to Powhatan Mining Company, Baltimore, Maryland. Shipments were made to Baltimore.

Chromite

Little Castle Creek Mine. Sec. 2, T. 38 N., R. 4 W., M. D. This property was mapped and drilled by the U. S. Bureau of Mines and the U. S. Geological Survey. Leased to Manley M. Brown of Dunsmuir. Shipments were made to Portland and Yreka.

Montrose Mining and Milling Co., Max Schmidt, pres., built a hundred-ton capacity chrome-ore concentrating mill at Castella. Ore has been received from the Forest Queen Mine, Shasta County, and from deposits in the Crow Creek district, Trinity County. Operated by Phillip Munko and L. D. Taylor of Dunsmuir. They will treat custom ore.

Round Bottom Mine. Sec. 5, T. 26 N., R. 10 W., M. D. Operated by Donald Woodrum of Redding. Five men employed. Shipping to Sacramento stockpile.

Copper

Mountain Copper Co. Ltd. Secs. 34, 35, T. 33 N., R. 6 W., M. D. This company is building a 300-ton flotation plant to produce copper and zinc concentrates which will be shipped to Great Falls, Montana, for treatment. A small production of copper is being shipped to Tacoma, Washington, for treatment.

Iron

Shasta Iron Co. Sec. 26, T. 34 N., R. 4 W., M. D. Leased to Lee Carrico and Melvin Gautier of San Francisco. Highgrade magnetite is being mined by power shovel and used as a heavy concrete aggregate in naval construction.

Pyrite

Hornet Mine. Sec. 35, T. 33 N., R. 6 W., M. D. Owned and operated by the Mountain Copper Co. Several hundred tons per day are being shipped to their plant at Martinez for the production of sulphuric acid. A small amount of copper is recovered in the process.

Talc

Ganim Gold Mines Co. Secs. 5-8, T. 32 N., R. 6 W., M.D. Joe S. Ganim, Schilling, president. Shipments of good grade talc are being made by leasers.

SISKIYOU COUNTY

Chromite

Burton Ranch Deposits. Patented land in sec. 24, T. 44 N., R. 8 W., M. D., owned by Fred C. Burton, Yreka. Shipments from several small deposits were made by J. R. Allison, Fred W. Burton and Wm. McCoy, Oliver W. Costello, and H. A. Schell and son.

Coggins Mine. Sec. 35, T. 39 N., R. 4 W., M. D. Leased to James K. Remsen of Grants Pass, Oregon. A new road has been built to the property and shipments are made to Sacramento.

Cyclone Gap (Mammoth) Mine. Sec. 15, T. 17 N., R. 5 E., H. A new mountain road has been built 22 miles from Waldo, Oregon, to this property. James K. Remsen of Grants Pass, Oregon, has six men employed mining chrome ore which is trucked 64 miles to the stockpile at Grants Pass, Oregon.

Doe Creek Mine. Sec. 32, T. 17 N., R. 5 E., H. J. B. Isgrid and G. P. Lily of Baker, Oregon, had nine men employed at this deposit in October. The ore was trucked 105 miles to the stockpile at Grants Pass.

Fairview Chrome Mine. Secs. 27, 34, T. 46 N., R. 11 W., M. D. This mine was purchased from Mrs. Dorothea Reddy Moroney by Franklin S. Pollak, Washington, D. C. A road has been built to the property and six men are employed under H. E. Ellickson, Mgr., shipping to Yreka stockpile.

Ladd Mine (Red Mountain Mine). Sec. 15, T. 46 N., R. 11 W., M. D. This mine is on the north side of Klamath river about 3 miles west of Hamburg. It is under lease to Ronald N. Knudsen of Yreka, who is planning to install an aerial tramline across the river. A road to the property along the north bank of the river from the bridge has been approved. Knudsen has been making deliveries of small lots from the Callahan district.

Kangaroo Mine. Secs. 12, 13, T. 47 N., R. 12 W., M. D. This property was developed by Phillip Davis and associates of San Francisco. A road is being built to the property by the U. S. Forest Service, and production should start in the spring.

Lady Gray Claims. Sec. 30, T. 45 N., 10 W., M. D. The county has built 4 miles of road to these claims in the McGuffy Creek district. They are being developed by Mrs. Dorothea Reddy Moroney, and shipments will be made to the stockpile at Yreka. The road will be continued about 2 miles to claims at a higher altitude. The U. S. Bureau of Mines and the U. S. Geological Survey mapped and drilled deposits in the McGuffy Creek area.

Peg Leg Mine. Sec. 25, T. 44 N., R. 8 W., M. D. This property was operated by Basil Wild and Carl Johnson who shipped to the stockpile at Yreka.

Deliveries of small lots of chrome ore from various locations to the stockpile at Yreka were also made by the following: John Baldwin, Cecilville; Fred P. Brown, Callahan; David Calkins, Hilt; J. W. Costello, Fort Jones; Clifford Crumpton, Happy Camp; Max Erwin, Fort Jones; E. A. Kinkle, Yreka; Fred Kramer, Fort Jones; V. Lindell, Yreka; Wm. Middell, Happy Camp; Rustless Mining Corporation, Sacramento; R. E. Shelly, Yreka; and U. S. Vanadium Corporation, San Francisco.

Copper

Gray Eagle Mine. Sec. 4 et al., T. 17 N., R. 6 E., H. The Newmont Mining Corporation is building a 600-ton flotation concentrator which will be in operation early in 1943. Copper concentrates will be shipped to the smelter at Tacoma, Washington.

Graphite

Elk Lake Graphite (Crystal) Mine. Sec. 7, T. 47 N., R. 11 W., M. D. This property, held by W. B. and Elwood Stewart of Etna, will be able to develop because of the new road being built along the Cook and Green trail to the property.

Quicksilver

Empire Canyon Mining Co. Sec. 13, T. 47 N., R. 8 W., M. D., Carl Yates, Yreka, Manager. A 25-ton Nicholas-Herreshoff furnace has been installed at this property.

Manganese

Attempts were made to mine and sort a shipping grade of manganese ore from the extensive deposits in the Fort Jones area, but were unsuccessful because of the high silica content of the ore.

TEHAMA COUNTY

Chromite

Wright, Dolbear & Co., San Francisco, built a road and operated a deposit in the Elder Creek district, sec. 16, T. 25 N., R. 7 W., M. D., under lease to George A. Applegarth and Lawrence B. Wright of San Francisco.

Small lots of chrome ore mined in Tehama County by Harry Moore and Harold Robinson of Platina were delivered to the stockpile at Anderson.

TRINITY COUNTY

Chromite

September Morn Claim. Sec. 9, T. 29 N., R. 11 W., M. D. John Diestelhorst of Redding built a road to this claim and drove an adit 40 feet. Ore was hauled to the stockpile at Anderson.

Sunny Slope Claim (Collins). Sec. 10, T. 29 N., R. 11 W., M. D. Several good outcrops occur on this claim and small lots were mined by Joe Shafter of Hayfork and other leasers.

Yellow Pine Claim. Sec. 17, T 2 N., R. 7 E., H. John E. Winters and Theodore G. Knowles shipped several hundred tons of high-grade chrome ore from this claim.

Additional small lots of chrome ore from Trinity County were delivered to Anderson by: Charles Benson, Hayfork; H. S. Cummings, Weaverville; E. V. Donner, Dallas Garvin, Redding; M. A. Palmer and E. H. Reynolds, Forest Glenn.

Manganese

Black Oak Mine. Sec. 5, T. 3 S., R. 6 E., H. Owned by A. C. Crossman and T. K. Tryee of Alderpoint. Shipments of oxide ores were made to Sacramento stockpile.

Coldwater No. 1 (White Estate). Secs. 8, 9, T. 4 S., R. 6 E., H. Leased to Ray Helmke, Alderpoint. Black oxide ore; interbedded in Franciscan formation was mined with a bulldozer and sorted. Shipments to Sacramento.

Hale Creek Mine. Sec. 26, T. 1 S., R. 6 E., H. Sid Killingsworth of Chico has several hundred tons of pink carbonate and silicate ore on the dump. A new road was built to the deposit.

Manganese Queen Mine. Sec. 25 or 36, T. 30 N., R. 12 W., M. D. A. Granzotto of Walnut Creek built a road to this deposit and made shipments to Anderson and Richmond.

McNight Manganese Mine. Sec. 17, T. 26 N., R. 12 W., M. D. James I. Scott & Co., Fortuna, mined black oxide ore from three adits on this property. The pink carbonate ore is also found and often carries native copper. Shipments were made to Sacramento stockpile. A new road was built to this deposit. Three trucks were hauling the ore 87 miles to the railroad at Alton.

CURRENT MINING ACTIVITY IN PLUMAS COUNTY

By C. A. Logan [*]

OUTLINE OF REPORT

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There has been marked activity in prospecting and locating mining claims for chromite and manganese oxide ores in Plumas County recently. Actual production has advanced so far that at a meeting of miners in Quincy early in August 1942, representations were made which resulted in a decision by Metals Reserve Company to establish a Purchase Depot at the County Fair Grounds near Quincy where these minerals will be purchased in lots of 10 tons or more. Work began on the site under the direction of W. R. Brown, Senior Engineer, R. F. C., August 14, and purchases are expected to start as soon as scales can be installed for weighing ore. Fletcher Hamilton, formerly State Mineralogist, will be in charge of the depot.

Asbestos

Asbestos Claims. The Asbestos No. 1, No. 2, and No. 3 claims were located June 30, 1942, on a promising deposit of amphibole asbestos in an old hydraulic pit on the west slope of Fales Hill, probably in sec. 25, T. 25 N., R. 7 E., M. D., 6¼ miles in an airline northwest of Spanish Ranch. The locators are A. A. Beuner, Frank Maurizio and R. E. Barrington, Quincy. Only a little work has been done so far. It is 9 miles by road from Spanish Ranch to the east side of sec. 25.

Chromite

The most active and at present most important chromite-producing area in the county is the vicinity of the upper course of South Fork of Rock Creek in secs. 8, 9, 16, and 17, T. 23 N., R. 9 E., M. D., 12 miles by road from Quincy. The chromite occurs in a large dike, now serpentine, but according to H. W. Turner originally peridotite or pyroxenite. This appears to be part of a very persistent belt traceable northward (except where covered by later andesite flows of mud and rock) from the Mother Lode gold belt. From Onion Valley where it is 4½ miles wide, it extends northwest to Yellow Creek, beyond which only a limited exposure remains above the Neocene volcanics. During World War I, the McCarty claims in the deep canyon of Middle Fork of Feather River were productive, but ore had to be packed out by mules.

White Pine, Spot, Cedar Flat Claims. E. R. Patterson et al. bought the White Pine, Spot, and Cedar Flat claims and have located 4 other claims all close to the corner common to secs. 8, 9, 16, and 17, T. 23 N., R. 9 E., M. D., 12 miles by road from Quincy. The work done, largely on the White Pine, is said to have exposed a body of chromite

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[*] District Mining Engineer, Sacramento Field District, California State Division of Mines. Manuscript submitted for publication August 31, 1942.

18 feet wide and several hundred feet long at a depth of 40 feet. This was not visited. It is claimed that 7 carloads of ore is piled ready for shipment (August 15), and probably 10 carloads more is in sight. A bulldozer was used to strip off the reddish-brown soil covering the vein.

The group of claims including and contiguous to the White Pine number 15 or more, being 8 claims long in a direction north of northwest. Louis Eddelbuttel, Frank Maurizio and associates, of Quincy, and Frank G. Myers, Stockton, are locators or lessees.

Other claims on which ore either mined or in sight is reported, are:

Green Ledge in S½ sec. 16, T. 23 N., R. 9 E., M. D., several carloads;

Fido Group, 3 or 4 carloads;

Cough Group, good prospects.

McCarty Nos. 1 to 6. This group, in the canyon of Middle Feather River, in secs. 15 and 16, T. 23 N., R. 9 E., M. D., is claimed by Frank Maurizio, Quincy. The old Last Chance road, from the Finger Board on the mountain road between Quincy and Onion Valley, runs 8 miles to Cleghorn Bar on the river. If it were repaired, as is claimed could be done for a few hundred dollars, it would give access to 25 chromite prospects including the McCarty claims where mining was done in 1918 and where several carloads of ore is said to be in sight. The other claims are undeveloped.

About 20 other chromite claims have been located and recorded in Plumas County thus far in 1942. Of these, only the following could be definitely located on a map from information given in the location notices:

Name of Claim	*Locator*	*Location*
General Wainwright	John Egbert, Jr. Ralph E. Jordan	S½ sec. 11, T. 23 N., R. 9 E., M. D.
General MacArthur	Ralph E. Jordan John Egbert, Jr.	S½ sec. 11, T. 23 N., R. 9 E., M. D.
Hudson	Harry Fuller Edward R. Smith	N½ NE¼ sec. 27, T 24 N., R. 8 E., M. D.
Hillside	Harry Fuller	N½ (?) sec. 9, T. 24 N., R. 8 E., M. D.
Florence	Harry Fuller	Sec. 16, T. 24 N., R. 8 E., M. D.
Snow White No. 1, 2, 3	Harry Fuller	(Prob.) sec. 6, T. 24 N., R. 8 E., M. D.

Robert G. Ridley, Stella M. Ridley, Charles G. Ridley, and John Forth have located claims for chromite. However, the notices are not sufficiently explicit as to location to permit placing the claims on the latest U. S. Forest Service map of Plumas National Forest.

Iron

Six claims have lately been located on an iron ore deposit in T. 26 N., R. 12 E., M.D. While the location by section is not given, they are probably near Hungry Creek, a branch of Indian Creek, flowing through secs. 6, 7, 8, 16, and 17. Hungry Creek Iron Mine No. 1 and Hungry Creek No. 2 were located by Charles Davis. Hungry Creek Iron Ore No. 3 to No. 6 inclusive are claimed by R. E. Barrington, Frank Maurizio and A. A. Benner, Quincy. The locators claim a substantial tonnage. It will probably prove to contain both hematite and magnetite as is usual in the region of Sierra Nevada granodiorite. It is 12 miles by road, part of it steep, from Taylorsville to a point 1 mile east of Hungry Creek in the vicinity of the claims.

Manganese

Former mining of manganese oxides has been carried on 2 miles southwest of Crescent Mills and on Mt. Hough and Arlington Heights 4 miles to 5 miles southeast of that place. The present activity is in the same districts but claims have also been located in other sections. Former producers were the *Braito* in sec. 26, T. 26 N., R. 9 E., M. D., and *Crystal Lake Group* in sec. 8, T. 25 N., R. 10 E., M. D. One, and possibly both of these, have lately been staked under new names. Some ore is mined and ready to haul to the new ore depot at Quincy.

Manganese Locations Made in 1942

Name of Claim	*Locator*	*Location*
Arlington	Myles Timmins Clinton Neer	(Prob.) sec. 12, T. 25 N., R. 9 E., M. D.
Arlington Heights	George Holloway	Adjoins Manganese No. 2
Barbarian	Frank Bear E. A. Pulliam	(Prob.) sec. 5, T. 25 N., R. 10 E., M. D.
Carbonate Manganese	John Egbert, Jr. Ralph E. Jordan	SW¼ sec. 8, T. 23 N., R. 10 E., M. D.
Gibraltar	Frank Bear E. A. Pulliam	(Prob.) sec. 5, T. 25 N., R. 10 E., M. D.
Lookout	Julia A. Underhill	"Adjoins Gallegos No. 1"
Lucky Hill	Herbert W. Weaver	Indefinite
Manganese King	Myles Timmins	SE¼ sec. 26, T. 26 N., R. 9 E., M. D.
Mt. Hough & M. H. No. 1	C. I. Drake	Sec. 8, T. 25 N., R. 10 E., M. D.
Sunset No. 4 to No. 9 (6 claims)	A. E. Williamson A. E. McKay W. J. McMillan	"Between Greenville and Almanor, above Wolf Creek, near Forest Service road intersection."

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins*

In Preparation

A bulletin to be published by the Division of Mines on MANGANESE IN CALIFORNIA is now in press. It will represent a cooperative enterprise between the United States Geological Survey, the California State Division of Mines (Geologic Branch), the University of California, and Stanford University.

The bulletin will contain several chapters: Economics of the industry, by Robert S. Kroger; manganese resources of California, by Parker D. Trask, Ivan F. Wilson, and Frank S. Simons; genesis and metamorphism of manganese deposits of the Coast Ranges and Sierra Nevada, by N. L. Taliaferro; tabulation of all known manganese deposits in California; a state map showing, by a four-fold classification, the location of all the manganese deposits, and, in addition, many other pertinent data. The map will be "Economic Mineral Map of California, No. 5—Manganese."

In This Issue

In the July-October 1942 issue of the JOURNAL, Mr. James M. Little contributed three geological papers on different tungsten deposits in the Sierra Nevada. In this issue, Mr. Little contributes a fourth, "Tom Cat Tungsten Property," and with it a small but pertinent geologic map.

Recent Publications on Strategic Minerals by the United States Geological Survey

A series of geological reports on strategic minerals has been issued by the United States Geological Survey during the past two years. These reports are the result of careful field investigations and mapping. The following references concern reports which describe deposits in the state of California:

Bull. 922-B: Quicksilver deposits of the Mount Diablo district, Contra Costa County, Calif., by Clyde P. Ross (1940)

Bull. 922-H: Tungsten deposits of the Atolia district, San Bernardino and Kern Counties, Calif., by D. M. Lemmon and J. V. N. Dorr 2d (1940)

Bull. 922-J: Chromite deposits in the Seiad quadrangle, Siskiyou County, Calif., by G. A. Rynearson and C. T. Smith (1941)

Bull. 922-K: Antimony deposits of the Wildrose Canyon area, Inyo County, Calif., by D. E. White (1940)

Bull. 922-L: Quicksilver deposits of the Mayacmas and Sulphur Bank districts, California, a preliminary report, by C. P. Ross (1941)

Bull. 922-O: Chromite deposits of the Pilliken area, El Dorado County, Calif., by F. G. Wells, L. R. Page, and H. L. James (1941)

Bull. 922-Q: Tungsten deposits in the Tungsten Hills, Inyo County, Calif., by D. M. Lemmon (1941)

Bull. 922-R: Quicksilver deposits in San Luis Obispo County and southwestern Monterey County, Calif., by E. B. Eckel, R. G. Yates, and A. E. Granger (1941)

Bull. 922-S: Tungsten deposits of the Benton Range, Mono County, Calif., by D. M. Lemmon (1941)

Bull. 931-B: Some quicksilver prospects in adjacent parts of Nevada, California, and Oregon, by C. P. Ross (1941)

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* Chief Geologist, Division of Mines.

Bull. 931-E: Tungsten deposits in the Sierra Nevada near Bishop, Calif., a preliminary report, by D. M. Lemmon (1942)

Bull. 931-Q: Quicksilver and antimony deposits of the Stayton district, Calif., by E. H. Bailey and W. B. Myers (1942)

Bull. 931-S: Manganese deposits in the Paymaster mining district, Imperial County, Calif., by J. B. Hadley (1942)

Bull. 936-D: Chromite and quicksilver deposits of the Del Puerto area, Stanislaus County, Calif., by H. E. Hawkes, Jr., F. G. Wells, and D. P. Wheeler, Jr. (1942)

Bull. 963-F: Quicksilver deposits of the Parkfield district, California, by Edgar H. Bailey (1942)

Information Service on Geological Work of the Federal Survey

The Department of the Interior, Geological Survey, Washington, D. C., has issued a series of mimeographed papers known as ''Information Service'' numbered under the designation ''P. N.'' Several of these brief abstracts cover the geology of mineral deposits in California and are of interest to the mining industry. They are, therefore, reprinted in the following pages.

DEPARTMENT OF THE INTERIOR INFORMATION SERVICE

By United States Geological Survey

CHROMITE DEPOSITS ON NORTH ELDER CREEK TEHAMA COUNTY, CALIFORNIA*

As a part of the investigation of domestic deposits of strategic minerals by the Geological Survey, United States Department of the Interior, the chromite deposits in the valley of North Elder Creek, secs. 8, 9, 16, and 17, T. 25 N., R. 7 E., Tehama County, Calif., have been examined and mapped by G. A. Rynearson of the Survey. The deposits are 36 miles from Red Bluff and can be reached by road, part paved and part graded dirt. They occur in a north-trending elongate mass of peridotite about 1¼ miles wide, which is flanked on the east by Cretaceous sediments that dip steeply east and on the west by schists that also dip east. The peridotite is mostly saxonite, but other varieties of peridotite, chiefly dunite, and a few bodies of pyroxenite are also present. All the peridotite is largely altered to serpentine, especially near the eastern and western contacts and along faults and zones of shearing. The dunite forms masses that are mostly small, very irregular but generally elongate in form, and widely scattered through the saxonite. They are larger and more numerous in the eastern part of the area than in the western part. Though chromite occurs as an accessory mineral in both saxonite and dunite, appreciable concentrations are found only in the dunite.

The principal chromite deposits are in the Mill Gulch area, in the old workings of the Noble Electric Steel Co., in the main Grau mine, and in the West Pit of the Grau mine.

Old Noble Electric Steel Co. Workings

Two chromite deposits, developed in what are called the Upper Workings and the Lower Workings, are in the NW¼SE¼ sec. 16. These were worked by the Noble Electric Steel Co. during the first World War. The geology of the Upper Workings is obscured by slides. The Lower Workings consist of a large open cut, two small cuts, a shaft which is now filled with mud, and a short opening on the east side of the gulch. The ore occurs in a tabular mass of dunite, which dips steeply northeast. The ore body strikes approximately N. 85° E. and dips N. 60°-70°. It is cut by a northward-trending dike. Remnants of ore frozen to the dike indicate that at least part of the ore mined was massive high-grade disseminated chromite, but the ore remaining is estimated to contain about 30 percent of chromite. If, as assumed, this ore body is 70 feet long, 10 feet thick, and extends 25 feet below the outcrop, it may contain 1750 tons of ore.

Mill Gulch Area

The Mill Gulch area, in the western part of the NE¼ sec. 16, is developed by means of four adits, now partly filled and caved, and several trenches and small open cuts. The elongate dunite mass in which the ore occurs trends northwest and has a moderate dip to the northeast.

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* Mimeographed report released in April 1942 by the Geological Survey, Department of the Interior. P.N. 185386.

All the dunite contains a little chromite, but only the dunite containing more than 10 percent of chromite is regarded as ore. The chromite grains in the ore are more or less concentrated in layers, which attain a thickness of several feet; the concentration of chromite ranges from less than 1 percent to nearly 100 percent.

The main ore body, exposed on the west side of Mill Gulch for a distance of 200 feet along the strike, has a maximum thickness of 32 feet and a vertical range of 75 feet. If, as assumed, its total length is 200 feet, its average thickness is 25 feet, its extent down the dip is 50 feet, and 10 cubic feet of ore will weigh one ton, the ore body is estimated to contain 25,000 short tons of ore. It is possible that the ore body extends as much as 100 feet down dip, in which case the amount of ore would be about 50,000 tons; and if it be further assumed that the ore body extends along the strike for 25 feet under the talus at its northwest end the estimated total would be 56,200 tons. Probably 1000 tons could be mined from other outcrops scattered about the area, and an unprospected ore body at the northwest end of the area may contain another 1000 tons. The total reserves in the area are thus believed to be at least 27,000 tons of indicated ore, and they may be as much as 58,200 tons of inferred ore. Analyses of 17 samples from the main ore body, made for Wright, Dolbear & Co., average 11.6 percent of Cr_2O_3, and range from 3.48 to 28.16 percent of Cr_2O_3.

Grau Mine

The Grau mine is in the NE¼ sec. 17. Its development work consists of a trench, an open cut, and 110 feet of underground workings in four adits.

The ore occurs in an irregular mass of dunite, which is surrounded by saxonite. Many faults and shears have broken the dunite mass and have helped to give it an irregular shape. The ore body consists partly of irregular stringers and pods of massive chromite and partly of disseminated chromite in dunite. No definite arrangement of the pods or layering of the disseminated chromite has been recognized, but the ore body as a whole trends about N. 80° W. and dips N. 30°–60°. Ore has been proved by the underground workings for 30 feet down the dip. If a length of 100 feet, an average thickness of 25 feet, and a depth of 30 feet are assumed, the ore body is estimated to contain 7,500 short tons of indicated ore, from which it is calculated that approximately 6250 short tons of concentrating ore containing 11 percent of Cr_2O_3 and 1250 short tons of crude ore containing 45 percent of Cr_2O_3 could be obtained. If the ore body extends another 20 feet in depth, it probably contains about 12,500 tons of ore. The dump is estimated to contain 1500 short tons of ore containing about 10 percent of Cr_2O_3.

West Pit of Grau Mine

The West Pit deposit, in the NW¼ sec. 17, is developed by two small pits, two trenches, and a shallow cut. The small tabular mass of serpentinized dunite that contains the ore strikes about N. 35° W. and dips moderately to the north-east. The ore consists of chromite irregularly disseminated in the dunite. In general it is low grade, but it includes small bodies of massive or high-grade disseminated chromite.

A weighted average of analyses of 25 samples made for Wright, Dolbear & Co. is 8.8 percent of Cr_2O_3. If the length is 100 feet, the average thickness 20 feet, and the depth down the dip 20 feet, the ore body contains about 4000 short tons; if, as is possible, the depth down dip is 40 feet, the amount will be double.

Minor Deposits

Scattered over the area mapped are 11 additional chromite deposits, but none of these appears to contain appreciable reserves.

Summary of Reserves

The foregoing estimates of reserves in the North Elder Creek area may be summarized as follows:

	Short tons	Average content of Cr_2O_3 (per cent)	Shipping ore or concentrates of shipping grade (short tons)
Indicated crude ore	1,250	45	1,250
Indicated concentrating ore	40,500	11	*8,150
Inferred concentrating ore	40,200	11	*8,040

* Concentration ration, 5:1.

CHROMITE DEPOSITS OF McGUFFY CREEK AREA SISKIYOU COUNTY, CALIFORNIA*

As part of the investigation of strategic minerals by the Geological Survey, United States Department of the Interior, the chromite deposits of the McGuffy Creek area in northern California have recently been studied by J. S. Livermore and F. G. Wells. The deposits were trenched and sampled by the Bureau of Mines.

The McGuffy Creek area lies on the northwest border of the Marble Mountains, a range within the Klamath Mountain system of northwestern California and southwestern Oregon. The area is in Siskiyou County, and includes parts of sec. 25, T. 45 N., R. 11 W., and of sec. 30 and 31, T. 45 N., R. 10 W. The altitude ranges from 3250 to 4850 feet, and the topography is rugged with steep slopes and many sheer cliffs. The nearest shipping point, Hornbrook, on the Southern Pacific railroad, is 43 miles from the area by road.

During the first World War, some development work was done on many claims, and a few tons of chromite was shipped.

Geology

The oldest rock of the area is gneissic diorite, and the next in age is an intrustive mass of periodotite. Small bodies of granite and diorite pegmatite were intruded later. The peridotite is of two kinds. The less abundant variety, though consisting mainly of olivine, contains on the average about 5 percent of pyroxene. It is recognizable in the field by its rather dark color and its rough weathered surface, from which crystals of pyroxene stand out in relief. The more abundant variety is dunite, a rock that consists almost entirely of fine- to medium-grained olivine. The weathered surfaces of the dunite are smooth, rounded, and reddish brown. The unweathered rock is olive green. All the chromite ore of the area is found in the dunite.

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* Mimeographed report released, May 26, 1942, by the Geological Survey, Department of the Interior. P. N. 187831.

The peridotite body strikes about N. 30° W. and dips W. 30°-50°, and its numerous principal joints have, in general, about the same attitude. So, also, do the structures in the chromite—the linear elements of the ore, the longer diameters of the ellipsoidal nodules, and the axes of the folds in the planar chromite.

There are two east-west normal faults of rather large displacement, as well as several minor faults.

The ore occurs in six more or less distinct forms—massive, disseminated, layered, lineate banded, nodular, orbicular.

The massive and disseminated ores grade into each other, and disseminated ore grades into dunite that contains only a few scattered grains of chromite. The chromite grains apparently have no systematic arrangement. Neither massive nor disseminated ore is common in the area.

The layered ore is composed of layers of almost solid chromite alternating with partly serpentinized dunite that contains scattered grains of chromite. The layers conform in general with the attitude of the intrusive mass, and the axes of the folds are parallel to the linear structure of the peridotite body. This type of ore is common.

Lineate banded ore has the same appearance as the layered ore on surfaces parallel to the strike, but sections across the strike appear spotted rather than banded and so reveal the linear structure. The streaks of chromite are parallel to the walls of the peridotite body and plunge N. 5°-20°. This type of chromite, like the layered ore, is common, and the two together make up most of the ore in the area.

Nodular ore consists of spherical or ellipsoidal nodules of solid chromite surrounded by partly serpentinized dunite. The ellipsoidal nodules have their major axes aligned parallel to the linear structure. This type of ore occurs only in the Black Spot claims, north of McGuffy Creek.

Orbicular ore consists of ellipsoidal bodies, each consisting of a small nucleus of coarse-grained chromite surrounded by a shell of serpentinized dunite, embedded in a matrix of fine-grained chromite. These ellipsoids also have their major axes oriented parallel to other linear elements in the peridotite.

The chromite appears to have segregated in the peridotite magma before the magma was intruded, forming parallel layers in some places and irregular bodies of massive, nodular, orbicular, or disseminated ore in others. During intrusion shearing stresses, caused by friction with the walls, resulted in linear or planar alignment of the mineral grains parallel to the elongation of the peridotite mass. Locally, these stresses also produced a folding of the layers and elongated the spherical nodules and the orbicles into ellipsoidal shapes. Some of the chromite was rolled and squeezed to such an extent that it flowed along the direction of least resistance and assumed the linear, pencillike form characteristic of the lineate ore.

Deposits

On the Veta Chica claim contorted, layered chromite ore crops out in an area about 500 feet long by 60 feet wide and is exposed to a depth of 30 feet. The only possible way to develop a large tonnage of this ore would be to mine practically the whole outcrop. The rock thus mined, however, would be, on the average, of too low grade to be put through a mill without sorting. Selective mining would yield only a small tonnage of ore of 15 to 20 percent Cr_2O_3.

The Cerro Colorado deposit consists of a vertical zone of layered ore, which is not so strongly contorted as that in the Veta Chica. The average width of the main zone is 3 feet, and the strike length is 400 feet.

Most of the shipments from the area during the last war came from the Veta Grande claim, where the deposit consists mostly of the lineate banded ore, in a zone about 20 feet wide and 125 feet long. Some very high grade ore is said to have been mined from the large pit, but now little is in sight.

On the Mary Lou claim there are several pits and a short adit in dunite just north of the gneissic diorite contact. The remaining reserves here probably do not amount to more than a few hundred tons.

Suggestions for Prospecting

In the two deposits presumably containing the greatest reserves—the Veta Chica and the Cerro Colorado—diamond drilling would probably be the best method of prospecting. Both of these ore bodies are well delineated on the surface by outcrops and pits, but their dimensions down the dip can be determined only by exploration. Prospecting on the other claims should consist of trenching to uncover the ore.

THE FAIRVIEW AND LADD CHROMITE DEPOSITS SISKIYOU COUNTY, CALIFORNIA*

As a part of the investigation of domestic deposits of strategic minerals by the Geological Survey, United States Department of the Interior, the Fairview and Ladd chromite deposits have been examined and mapped by G. A. Rynearson of the Survey. The Fairview mine, in secs. 27 and 34, T. 46 N., R. 11 W., is 49 miles by paved and graded dirt roads from the stockpile of the Metals Reserve Co. at Yreka. The Ladd mine, on the line between secs. 16 and 21, T. 46 N., R. 11 W., is 57 miles by similar roads from Yreka. Each of these mines produced chromite during the first World War, and 50 tons of ore was recently shipped from the Fairview mine.

The deposits were briefly described by G. A. Rynearson and C. T. Smith in Geological Survey Bulletin 922-J, published in 1940. The chromite occurs in a large sill-like mass of peridotite intruded into chlorite schists and gneissic diorite.

Fairview Mine

The Fairview ground comprises four claims, owned by F. S. Pollak of Washington, D. C. An adjacent claim is owned by Hollis Anderson of Scott Bar, Calif. Development consists of 13 open cuts in ore.

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* Mimeographed report released October 27, 1942 by the Geological Survey, Department of the Interior. P.N. 6990.

Chromite in layers, irregular stringers, and disseminated grains is concentrated in two major zones parallel to the foliation of the dunite, which strikes N. 30° W. and dips 30°-70° S. The layers of chromite range in thickness from a fraction of an inch to nearly a foot. In some places they grade imperceptibly into rock with evenly disseminated grains of chromite. The layers are contorted here and there, forming both large and small folds.

The largest concentrations of chromite are exposed in cuts 5, 6 and 7, near the common corner of the four Fairview claims. In these cuts the two ore zones are 1 to 5 feet thick and are separated by 3 to 25 feet of waste. An ill-defined zone of brecciation suggests that the zones in cuts 6 and 7 are the offset continuation of the zones in cut 5, but they may belong to a different body.

Ore exposed in cuts 2, 3, and 4 and in several intervening outcrops may also represent a continuation of the zones in cut 5, which it resembles in appearance and attitude. Cuts 11, 12, and 13 seem to be mostly mined out, but their location suggests that they may be in a southward continuation of the two major zones. Considerable trenching would be needed to show whether the zones are continuous.

The following grab samples, taken from channels across the strike of the ore zones, indicate that "low-grade A" ore can be mined from cuts 5, 6, and 7. Some hand sorting will be necessary, and the resulting ratio of shipping ore to concentrating ore will probably be about 2 to 1. The ratio for other parts of the property may be about 1 to 1.

Channel number	*Open cut*	*Cr_2O_3 (percent)*	*Thickness of Ore (feet)*
1	7	31.18	1.2
2	7	44.50	1.5
3	7	37.01	2.0
4	6	39.32	3.0
5	5	41.63	2.5
6	5	38.12	2.0
7	5	40.71	3.0
8	4	31.46	1.2

In the following estimates of reserves, an ore factor of 10 and a factor of ½ to compensate for topography have been entered in all of the calculations. The ore zones in cut 5, on the assumption that their length is 75 feet, their average aggregate thickness 4 feet, and their maximum depth down the dip 50 feet, are estimated to contain 500 tons of shipping ore and 250 tons of concentrating ore. The ore zones in cuts 6 and 7, assumed to be 80 feet long, 4 feet in average aggregate thickness, and 75 feet in maximum depth, contain about 800 tons of shipping ore and 400 tons of concentrating ore. If the zones are continuous between cut 4 and cuts 6 and 7, with a length of 250 feet, an average aggregate thickness of 3 feet, and a maximum depth down the dip of 120 feet, the deposit may yield 3000 tons of shipping ore and 1500 tons of concentrating ore. If the zones are continuous from cut 2 to cuts 6 and 7, the reserves may amount to as much as 8000 tons of shipping ore and 8000 tons of concentrating ore.

Ladd Mine

The Ladd mine, also known as the Dolbear or Klamath chrome mine, is owned by John Ladd of Seiad Valley, California, and is leased to Mrs. D. R. Moroney of Hamburg, Calif. It is developed by 16 open cuts and 4 short adits. Four disconnected ore bodies are exposed in the workings, and another has been prospected by two small cuts about 500 feet southwest of the glory hole.

The ore body exposed in the upper cuts has the form of a flat lens. Its middle part consists of irregular stringers of chromite, indistinctly layered chromite, and high-grade disseminated chromite; its flanks contain sparsely disseminated clusters of chromite grains and thin layers of massive chromite. The ore body dips steeply to the west at the north end and steeply to the east at the south end. It is offset by a low-angle fault with a throw of about 40 feet. The ore has a maximum thickness of 15 feet but averages about 10 feet, and the ratio of shipping ore to concentrating ore is estimated at 1 to 2. If the length is 60 feet, the average thickness 10 feet, and the maximum depth 85 feet, the ore body contains about 765 tons of shipping ore and 1785 tons of concentrating ore. If the ore body extends another 40 feet beneath the fault at the north end, it may contain 1050 tons of shipping ore and 2450 tons of concentrating ore.

A similar ore body exposed in the lower cuts has an average thickness of about 3 feet. It is cut off by a low-angle fault at the north end but may be represented by a small amount of ore exposed in the next cut northwest. If its length is 90 feet and it extends to a maximum depth of 60 feet, the ore body contains about 650 tons of shipping ore and 700 tons of concentrating ore. It may extend another 30 feet northward beneath the fault, in which case the reserves would be 800 tons of shipping ore and 1000 tons of concentrating ore.

The glory hole is badly caved. Although a little ore is exposed in its walls, most of its ore seems to have been taken out. The ore body in the east cuts also has been mined out except for a few small masses of high-grade chromite.

CHROMITE DEPOSITS NEAR SAN LUIS OBISPO, CALIFORNIA*

As part of the investigation of domestic deposits of strategic minerals by the Geological Survey, United States Department of the Interior, the chromite deposits in the vicinity of San Luis Obispo, Calif., were studied and mapped by C. T. Smith and A. B. Griggs in the winter of 1940. In the fall of 1941 the Geological Survey and Bureau of Mines, in a cooperative project, explored the Castro and Sweetwater deposits and sampled the dumps of the Trinidad and New London mines.

The chromite of the San Luis Obispo area occurs in serpentinized dunite and peridotite—both commonly called serpentine—which form lenses and discontinuous belts trending northwestward. The principal deposits are on the western slope of the Santa Lucia Mountains, 3 to 10 miles north and west of the city of San Luis Obispo, at altitudes of 1000 to 2500 feet above sea level. The district has produced about 50,000 tons of lump ore and 1700 tons of concentrates since 1870.

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* Mimeographed report released in December 1942 by the Geological Survey, Department of the Interior. P. N. 8533.

The deposits are of two general intergrading types—lenses of massive high-grade ore and ill-defined bodies of low-grade ore consisting of chromite grains disseminated through serpentinized dunite. Chemical analyses of cleaned chromite indicate that the chromic oxide (Cr_2O_3) content of the mineral ranges from 47 to 57 percent, and that the chromium-iron ratio ranges from 3.2 to 2.2, averaging about 2.6. The massive ore, therefore, is readily salable, and the disseminated ore will yield concentrates containing 40- to 45-percent chromic oxide with a Cr.Fe ratio higher than 2:1.

Averages of chemical analyses of cleaned chromite from the San Luis Obispo district

Name of mine	Number of samples analyzed	Percent of Cr_2O_3	Cr/Fe ratio
Castro	2	47.29	2.4
Eucalyptus No. 1	1	54.65	2.7
Norcross	1	51.45	2.6
Pick and Shovel	4	54.45	3.0
Seeley	5	52.69	2.5
Sweetwater	4	51.73	2.6
Trinidad	1	45.78	2.2

The serpentinized rock in which the chromite is found is highly sheared, and the structure of many of the deposits is very complex. Most of the high-grade lenses are bounded and broken by faults, and much of the ore has been thoroughly crushed. Although in some mines, the distribution of the ore bodies is irregular, in others, the ore occurs in a definite zone. As shearing commonly follows the margins of high-grade ore bodies, some large masses of ore have been strung out into a series of lenses connected by thin streaks of finely crushed chromite. The high-grade lenses are ordinarily associated with or enclosed in disseminated ore, so that mining operations on milling-grade deposits usually yield some lump ore.

The reserves in the San Luis Obispo district consist almost entirely of disseminated milling-grade ore, as all of the known deposits of shipping-grade ore have been mined out. The Bureau of Mines has blocked out 8,400 short tons of ore averaging about 30 percent of chromic oxide. Some 50,000 tons of ore containing 7 to 10 percent chromic oxide are indicated, but not actually blocked out, in the various mines of the district, and a possible additional reserve of 45,000 to 72,000 short tons of ore containing 5 to 10 percent of chromic oxide is inferred from the geologic relations of some of the deposits. Systematic prospecting along known zones and in undeveloped deposits should greatly increase the known reserves.

MANGANESE DEPOSITS OF THE LADD-BUCKEYE AREA NEAR TRACY, CALIFORNIA *

Manganese deposits occur in the Ladd-Buckeye area, 65 miles southeast of San Francisco and 10 to 20 miles south of Tracy, in San Joaquin and Stanislaus Counties, Calif. The area is 13 miles long and 2 to 4 miles wide and lies in mountainous country that is accessible over good roads. The manganese deposits have been studied by a party of geologists from the Geological Survey, United States Department of the Interior, as part of the program for the investigation of strategic minerals. The field party was under the direction of P. D. Trask, W. G. Pierce, and S. G. Lasky. The Bureau of Mines, United States Department of the Interior, carried on exploration and sampling work at the Ladd and Buckeye mines.

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* Mimeographed report released February 16, 1943, by the U. S. Geological Survey, Department of the Interior. P. N. 13091.

A geologic and topographic map of the region on a scale of 1,000 feet to the inch was made with the aid of airplane photographs and ground control. The workings of the four principal mines were mapped on scales of 25 and 40 feet to the inch, and detailed geologic and topographic maps of the environs of these mines were made on scales of 100 and 250 feet to the inch.

The manganese ore is found in lenses of white chert, associated with thin-bedded red chert in the Franciscan formation, of Jurassic (?) age. The Franciscan formation consists mainly of sandstone and shale. The chert and the manganese deposits occur chiefly at the northwest and southwest ends of the area mapped.

The ore bodies are mainly elliptical in outline. Most of them are less than 200 feet in length, about one-half to four-fifths as broad as they are long, and 5 to 10 feet thick, but the East ore body at the Ladd mine is 800 feet long and 35 feet in maximum thickness.

The ore is of two types, massive and disseminated. Both types consist of oxide ore at the surface of the ground and of primary ore at depth. The depth of oxidation is ordinarily between 50 and 200 feet, being less in general on the sides and bottoms of canyons than on the crests of ridges. The primary ore in the massive type consists chiefly of light-gray rhodochrosite (manganese carbonate), though in places it contains a little bementite (hydrous manganese silicate) and hausmannite (a high-grade form of manganese oxide containing when pure 72 percent of manganese). The primary ore in the disseminated type consists of a mixture of bementite and rhodochrosite embedded in a matrix of chert. The average manganese content of the primary massive ore is about 40 percent and that of the primary disseminated ore about 20 percent.

The ore bodies are believed to be of sedimentary origin but they have been slightly modified in places by hydrothermal action, which has caused some recrystallization and redistribution of the ore minerals. Both the primary ore and the adjoining country rock are cut in places by thin veins of quartz and rhodochrosite and bementite.

The region has produced more than 50,000 tons of ore averaging 45 percent manganese and 13 percent silica. Some 30,000 tons has come from the Ladd mine, 17,000 tons from the Buckeye mine, 3000 tons from the Liberty mine, 2300 tons from the Cummings or Lone Tree mine, and 1000 tons from 10 other deposits.

The tonnage of ore in the mines was computed from maps and sections prepared by the Geological Survey together with data from drill records of the Bureau of Mines. The grade was computed from assays made by the Bureau of Mines. The reserves in the region are estimated to be about 200,000 tons averaging approximately 20 percent manganese. Of this, 190,000 tons is oxide ore and the remainder is manganese carbonate (rhodochrosite) ore. By means of careful hand-sorting perhaps as much as 7000 tons of oxide ore averaging 45 percent manganese, or 25,000 tons averaging 35 percent manganese, might be obtained from the region. About 7000 tons of carbonate ore averaging 35 percent manganese might be procured. Most of the reserve ore is in the Ladd mine.

QUICKSILVER DEPOSITS OF THE NEW IDRIA DISTRICT SAN BENITO AND FRESNO COUNTIES, CALIFORNIA*

As part of the investigation of domestic deposits of strategic minerals by the Geological Survey, United States Department of the Interior, a party of the Survey's geologists headed by Edwin B. Eckel has completed an examination of the quicksilver deposits of the New Idria district, which is in central California, 140 miles southeast of San Francisco.

The New Idria district is one of the most productive and most promising quicksilver-mining districts in America. Its recorded production is 396,443 flasks of quicksilver, valued at nearly 24 million dollars. More than 98 percent of this output has come from the New Idria mine and the related San Carlos mine; the remainder has come from nearly 20 other deposits. The New Idria mine is the second largest all-time producer in America. It was discovered in 1853 and, except for 1920-21, has been operated continuously ever since. With a larger furnace capacity than any other quicksilver mine in the world, it is at present treating 400 tons of ore a day and is adding about 5,000 flasks of quicksilver a year to the Nation's supply.

It is expected that a production rate of about 5,000 flasks annually can be maintained for 2 to 5 years and possibly longer if the price of quicksilver is $125 per flask or higher. The assured and probable reserves are estimated to contain between 20,000 and 35,000 flasks of quicksilver, more than half of which is in old low-grade mine dumps. The outlook is rather bright for finding new ore bodies either in the New Idria mine or, more likely, in one or more of the adjacent similar deposits, which have not been so thoroughly explored. It is clear that additional reserves of ore should be sought out and developed while quicksilver prices are high, for the reserves now known are of marginal character—that is, their grade is so low that any marked drop in the price of quicksilver would force most of the mines now operating in the district to shut down.

Geologically, the district consists of a large oval dome of strongly sheared serpentine that is surrounded by sandstone of the Franciscan formation and by shale and sandstone of the younger Panoche and other formations. The rock strata along the northeast side of the dome are crumpled and overturned, and on that side an irregular thrust fault, called the New Idria fault, forms the contact between the Panoche formation and older rocks. The New Idria fault has the general shape of a twisted sheet of corrugated iron, inclined to the southwest. Steeply dipping normal faults encircle the other sides of the dome and dip away from its center.

The quicksilver deposits consist of the mercury sulphide mineral cinnabar, which fills veins and stockworks of fractures in altered rocks.

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* Mimeographed report released November 12, 1941, by the Geological Survey, Department of the Interior. P. N. 165300.

The richest deposits, including the New Idria and San Carlos, are in silicified beds of the Panoche formation beneath the New Idria thrust fault. The ore-bearing silicified zones are beneath inverted troughs, or ''corrugations,'' in the fault plane. Some of the ore shoots within these troughs are controlled by bends in the strike of the fault that are similar to the bends that form the main troughs, but others are controlled by changes in dip and lie beneath low-dipping segments of the fault plane. Several minor deposits occupy fractures in altered Panoche rocks above the normal faults on the south and west sides of the dome, and still others occur in silica-carbonate rock derived from serpentine.

NEW METHODS FOR DETERMINATION OF MOLYBDENUM IN SCHEELITE*

A new method of evaluating certain deposits on the site of discovery, which will assist in the minerals war production program, has been developed by the Geological Survey, it was announced today by Secretary of the Interior Harold L. Ickes. An improved laboratory method of making accurate chemical determinations of molybdenum in tungsten ores has also been perfected.

Both methods are for determining the molybdenum content of scheelite, a common domestic ore of tungsten. In the past the presence of molybdenum in scheelite has been detected only by testing in assay laboratories. One of the Survey's new testing methods—a fluorescence method—may be used upon deposits as they are discovered with results sufficiently accurate to permit a better appraisal of the ore without requiring actual mining operations to determine its value.

The intensive search for tungsten, begun by the Survey in 1938, has met with success, although considerable scheelite with undesirable molybdenum content has been encountered. Most of the scheelite in the contact-metamorphic deposits of the western states contains at least a trace of molybdenum, and at many localities the scheelite mineral contains as much as half a percent. As commercial scheelite concentrates containing more than 0.4 percent of molybdenum are subject to a price penalty, these methods of testing will be useful to persons engaged in developing, mining, or milling scheelite ores.

One of the methods, which is intended for use in the field, depends on fluorescence; the other, an improved assay method, depends on colorimetric chemical analysis.

By the fluorescence method, the molybdenum content of scheelite can be determined visually in the field by any good observer equipped with the customary ultra-violet lamp. This method is based on the discovery that the fluorescence color of scheelite is directly related to the proportion of molybdenum contained in the crystal lattice of the mineral. In general, concentrates that are not penalized for molybdenum can be made from any scheelite that fluoresces distinctly blue; those that fluoresce white are borderline cases containing roughly from 0.35 to 1.0 percent molybdenum; and scheelite that fluoresces distinctly yellow contains more than 1 percent. More exact quantitative determination of the molybdenum content of any scheelite containing less than 4 percent can quickly be made in the field by comparing the fluorescence color of the powdered mineral with fluorescence colors of powders of known composition, which are permanently mounted on a card.

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* Mimeographed report released July 16, 1942, by the Geological Survey, Department of the Interior. P. N. 611.

The first step in developing this method was made by R. S. Cannon, Jr., a geologist of the Survey, while studying tungsten deposits in the Seven Devils mining district of Idaho. Having observed that the fluorescence color of the scheelite varied considerably, Cannon conceived the idea that there might be a quantitative relationship between the fluorescence color and the molybdenum content. This idea was put to the test as soon as possible by studies carried out in the Chemical Laboratory of the Geological Survey. F. S. Grimaldi made complete chemical analyses of selected samples of scheelites and powellites from the Seven Devils and western districts. K. J. Murata at the same time prepared a series of synthetic compounds ranging in composition from pure calcium tungstate to pure calcium molybdate. It was then found that the fluorescence color given by all these materials of known composition varied systematically, so that it could be used as a means of estimating molybdenum.

With the type of ultra-violet lamp commonly used in prospecting for scheelite, Murata found that the fluorescence colors of the finely powdered synthetic preparations are bright blue for pure calcium tungstate, paler blue for preparations containing traces of molybdenum, and neutral white when the molybdenum content is about 0.5 percent. As the molybdenum content rises above 0.5 percent, the fluorescence color becomes increasingly yellow. It is strongly yellow for a compound containing 4.8 percent molybdenum; but, strangely enough, it remains of the same shade for any compound containing a higher percentage. The method accordingly serves to determine quantitatively the proportion of molybdenum—in the tungsten mineral, not in the sample—up to a practical limit of about 4 percent. But if the material shows the yellowest possible hue, it may contain any percentage of molybdenum between 4.8 and 48, which is the percentage in pure powellite.

The results obtained from the synthetic compounds were checked by fluorescence tests on chemically analyzed natural minerals, with very satisfactory results. For example, one scheelite sample from the Nightingale mine in Nevada was estimated from its fluorescence to contain considerably less than 0.05 percent molybdenum; chemical analysis showed 0.014 percent. Another scheelite, from the Tungstar mine in California, was estimated to contain 0.57 percent molybdenum on the basis of its fluorescence color; chemical analysis showed 0.51 percent. A third scheelite, from the Seven Devils district, was found to contain 1.20 percent molybdenum by chemical analysis, confirming a previous estimate of 1.18 percent from the fluorescence color.

For field use, a series of finely powdered synthetic preparations, or natural minerals, of known composition are permanently mounted in circular areas on a black card, being placed in order of increasing molybdenum content and mounted in a way that does not interfere with their fluorescence. On the cards that are being distributed to Survey geologists currently engaged in looking for tungsten ores, there are twelve standard synthetic preparations. Pure calcium tungstate is followed in sequence by compounds containing 0.05, 0.19, 0.33, 0.48, 0.72, 0.96, 1.4, 2.4, 3.4, and 4.8 percent molybdenum, and finally by one of pure calcium molybdate, which is 48 percent molybdenum. Alternating with the circles covered with powder are circular holes of the same size. The card is used by placing a hole over a powdered sample of the scheelite to be tested and comparing the fluorescence color of the sample with those of the adjacent standards. By trying one hole after another, the sample will be found to have a fluorescence color, and hence a composition, between that of two adjacent standards. The composition can be further narrowed down by observing which of these standards the sample most nearly resembles. The accuracy of the determinations could be increased by mounting a larger number of standards on the comparison card.

The improved colorimetric method, which was developed by F. S. Grimaldi, of the Survey's Chemical Laboratory, permits rapid, precise determination of molybdenum, when it does not exceed two percent, in specimens of scheelite, or in any molybdenum-bearing ores or concentrates, wherever laboratory facilities and the services of a trained chemist are available. This method eliminates the uncertainties of the usual colorimetric determinations, made with ether extractions, and obviates the need for the standards used heretofore. A stable amber to red molybdenum-thiocyanate color is developed in water-acetone solutions, ammonium citrate being used to eliminate interference by tungsten, and this color is matched by adding standard molybdenum solution to a blank.

MINERAL EXHIBIT AND STATISTICS

ACCESSIONS TO THE EXHIBIT

By Henry H. Symons*

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of economic and academic value. It ranks among the first five such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other States and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and sightseers. In addition to its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the Division of Mines, as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the exhibit are the following:

21097 NICKELIFEROUS PYRRHOTITE. Locality: Sudbury, Ontario, Canada. Donor: Louis B. May. August 1942. In Case 107.

21098 SHEELITE (tungsten ore) in tactite showing the contact with grantitic rock. Locality: Jackass Meadows, Tuolumne County, California. Donor: O. P. Jenkins. August 1942. In Case 238.

21099 CHRYSOCOLLA and MALACHITE. Locality: Live Oak shaft of Inspiration mine at Globe, Arizona. Donor: John Dunn. September 1942. In Case 139.

21100 SCHEELITE. Locality: Alpine County, California. Donor: George L. Gary. September 1942. In Case 201.

21101 SCHEELITE in PYRRHOTITE. Locality: J. B. Sivori property at Confidence, Tuolumne County, California. Donor: Otis D. Welsch. September 1942. In Case 313.

21102 MAGNESIUM metal. Locality: Permanente, Santa Clara County, California. Donor: George L. Gary. September 1942. In Case 802.

21103 CHROMITE from which the surrounding serpentine has all been leached. Locality: Sousa Ranch chrome mine, San Luis Obispo County, California. Donor: Todd B. Elliott. September 1942. In Case 302.

21104 ZINC ORE. Locality: Old mine near Sneedville, Tennessee. Donor: Alfred K. Dolen. October 1942. In Case 314.

21105 MANGANESE ORE (high grade)—probably containing hausmannite, pyrolusite, and psilomelane; with some impure limestone. Locality: Irish Hill mine, Johe Ranch, San Luis Obispo County, Caliifornia. Donor: Shelby L. Elliott. October 1942. In Case 208.

21106 CHROMITE (high grade)—showing large crystals. Locality: Aurora quicksilver mine, Idria, San Benito County, California. Donor: Henry H. Symons. October 1942. In Case 302.

21107 CHROME ORE (concentrating grade). Locality: Gray Eagle mine, Glenn County, California. Donor: O. P. Jenkins. October 1942. In Case 302.

21108 MANGANESE ORE showing native copper. Locality: Blue Jay mine, Scott property, on Mad River, Trinity County, California. Donor: O. P. Jenkins. October 1942. In Case 236.

21109 FLUORITE (CaF_2). Locality: Deming, New Mexico. Donor: Mrs. C. H. Mikelson. November 1942. In Case 406.

21110 CINNABAR (HgS); high-grade quicksilver ore. Locality: Sulphur Bank mine, Lake County, California. Donor: Stanley Bosanka. November 1942. In Case 212.

21111 CHROMITE. Locality: Cyclone Gap mine, near Happy Camp, Siskiyou County, California. Donor: A. C. Hamrick. December 1942. In Case 302.

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* Statistician and Curator, Division of Mines.

REVIEW OF CALIFORNIA MINERAL PRODUCTION FOR 1942

By Henry H. Symons *

The total value of the mineral production of California for the year 1942 is conservatively estimated to be $379,483,000. This is partly detailed in the tabulation below but as there are more than 60 mineral substances on California's commercial list, figures on the most important items only are available at this early date. The production report forms are being mailed to operators in all mineral lines; from these a detailed report will be compiled for publication.

The estimated total of $379,483,000 is an increase of approximately $5,157,000 over the 1941 total. The principal substances showing increases in value over the previous year were petroleum, cement, natural gas, miscellaneous stone, borates, potash, quicksilver, tungsten, chromite, manganese ore, iron ore, lead, zinc, and the industrial mineral group. Important minerals to register a decrease in value were gold, silver, and copper.

Petroleum output showed an increase of about 16,854,000 barrels in amount, and about 5 percent in value, over that of the previous year. The estimated quantity of crude oil was 246,509,000 barrels for 1942. There were no changes in crude petroleum prices during the year, but the trend of production was toward heavier oils. Natural gas showed an increase in both amount utilized and value, compared with 1941.

Reports of the mint and smelters show the output of gold to be much less than in 1941. The state's yield of tungsten, quicksilver, lead, zinc, chromite, and manganese showed marked increases during the year, but copper, gold, and silver showed decreases. The output of quicksilver and tungsten each exceeded the million-dollar mark as did the gold output.

Of the structural group, cement, miscellaneous stone, brick, and magnesite all showed increases in amount and value over 1941. The cement production was the largest in the history of the industry in California; and all the plants approached capacity output. Stimulated business conditions and national defense increased the demand for many substances in the miscellaneous industrial mineral group, and production of these minerals showed a marked increase in total value. The saline group also showed an increase in total value, all of the important items (borates, potash, salt, soda, and iodine) registering increases in output over that of the previous year.

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* Statistician and Curator, Division of Mines.

Table 1.—California Mineral Production—1942

Value in dollars	Quantity	Material
29,785,000	851,000 fine ozs.	Gold
908,000	1,403,000 fine ozs.	Silver
11,854,000	-------------------	Other metals, including chromite, copper, iron ore, lead, manganese ore, molybdenum ore, platinum group metals, quicksilver, tungsten ore, and zinc
228,021,000	246,509,000 bbls.	Petroleum
22,953,000	399,189,000 M cu. ft.	Natural gas
36,822,000	24,067,000 bbls.	Cement
20,000,000	-------------------	Miscellaneous stone, including crushed rock, sand, and gravel
3,740,000	-------------------	Brick and hollow building tile
2,500,000	-------------------	Other structural materials, including bituminous rock, granite, lime, magnesite, marble, sandstone, and slate
8,750,000	-------------------	Miscellaneous industrial minerals
14,150,000	-------------------	Salines, including borates, potash, iodine, salt, soda, and others
379,483,000	total	

LABORATORY

ADDITIONS TO BULLETIN 113

By George L. Gary*

Since 1866 many lists have been published showing localities of California minerals. The last one, ''Minerals of California,'' by Adolf Pabst, was published in 1938 by the Division of Mines as Bulletin 113.

It is the intention of the Division of Mines to publish in the quarterly CALIFORNIA JOURNAL OF MINES AND GEOLOGY new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Following are current additions to Bulletin 113:

121. **Cubanite**, a copper and iron sulphide, $CuFe_2S_3$, was reported to be associated with pyrrhotite, pyrite, and sphalerite in the ore from the Daulton mine, 1 mile southeast of Daulton Station in Madera County.
122. **Chrysotile asbestos** was reported on the Chester J. Rolff Ranch at Chicago Park, on the Colfax-Grass Valley road in Nevada County.

Corrections as well as additions will be noted in the Journal, when called to our attention.

LIBRARY

LIBRARY REPORT

By Henry G. Hubbard **

OUTLINE OF REPORT

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INTRODUCTION

The library of the Division of Mines contains more than 6,000 selected volumes on mines, mining, and allied subjects. It is also the repository for reports and bulletins of technical departments of Federal and State governments and educational institutions both domestic and foreign. Current copies of newspapers published in the mining centers of the State are also available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

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* Mineral Technologist, Division of Mines.

** Librarian, Division of Mines.

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY AND UNITED STATES BUREAU OF MINES

The library of the Division of Mines has available for public reference the following publications of the United States Geological Survey: Annual Reports, Monographs, Professional Papers, Bulletins, Water-Supply Papers, Mineral Resources, Folios of the Geologic Atlas of the United States (broken file), Maps with Descriptive Text (broken file), Administrative Publications (broken file); and the following publications of the United States Bureau of Mines: Bulletins, Technical Papers, Economic Papers (broken file), Mineral Resources of the United States, Monographs (broken file), Reports of Investigations, Information Circulars.

Reports on California recently received from the Survey and Bureau of Mines include:

U. S. Geological Survey

Bulletins

931-B Some Quicksilver Prospects in Adjacent Parts of California, Nevada and Oregon.
931-E Tungsten Deposits in the Sierra Nevada near Bishop, California.
932-A Geophysical Abstracts, January-March, 1941.
914 (Correction Sheet) Microscopic Determination of the Ore Minerals.

Water Supply Papers

868-A Investigations of Methods and Equipment used in Stream Gaging (Part 1).
868-B Investigations (Part 2).
879 U. S. Surface Water Supply (Part 9) Colorado River Basin.

Topographic Maps

Devore Quadrangle, San Bernardino County.
Firebaugh Quadrangle, Fresno and Madera counties.
Ontario and Vicinity Quadrangle, San Bernardino County.
Prado Quadrangle, San Bernardino, Riverside and Orange counties.
Gausti and Vicinity Quadrangle, San Bernardino and Riverside counties.
Swarthout Quadrangle, Los Angeles County.
Waterman Mountain Quadrangle, Los Angeles County.

Professional Paper

195 Geology of the Kettleman Hills Oil Field, California.

U. S. Bureau of Mines

Bulletins

431 Mechanical Concentration of Gases.
438 Quarry Accidents in the United States, 1939.
439 Some Essential Safety Factors in Tunneling.
440 Metal and Nonmetal Mine Accidents in the U. S., 1939.

Technical Papers

632 Theoretical calculations for explosives.

Reports of Investigations

No. 3564; 3567; 3569; 3570; 3571; 3574; 3576; 3578; 3580; 3582-3584; 3589.

Information Circulars

6884-R; 7164; 7169-7174; 7177; 7179; 7182-7183.

PUBLICATIONS OF STATE SURVEYS

A broken file of mining and geological publications, issued by the organizations listed below, may be consulted in the library of the Division of Mines.

Alabama Geological Survey, University.
Alaska (Territorial Commissioner of Mines), Juneau.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.

Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Indiana Division of Geology, Indianapolis.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology and Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
New York Science Division, Albany.
North Carolina Geological and Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological and Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

PUBLICATIONS OF FOREIGN GOVERNMENTS

Publications of the following foreign governments are received and current issues may be consulted in the library. Earlier issues of foreign-language publications have been loaned to the California Academy of Sciences in Golden Gate Park, because of the limited storage space at the Division's offices in the Ferry Building. They may, however, be consulted at the Academy.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum of Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia Geological Survey, Perth.

PUBLICATIONS OF FOREIGN AND DOMESTIC SOCIETIES AND EDUCATIONAL INSTITUTIONS

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.

Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Missouri School of Mines and Metallurgy, Rolla.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Forth Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
Stanford University, Palo Alto, California.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

CURRENT MAGAZINES

Current issues of the technical magazines listed below are on file in the reading room of the library, and may be consulted.

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

NEWSPAPERS

Current issues of the following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Courier Free Press, Redding, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles. California.
Mariposa Gazette, Mariposa, California.
Mining Press, Reno, Nevada.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Press-Citizen, Lone Pine, California.
Placer Herald, Auburn, California.
Placerville Times, Placerville, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

NEW BOOKS

Recent accessions to the library are the following books:

American Institute of Mining and Metallurgical Engineers, Industrial minerals and rocks (non-metallics other than fuels), Seeley W. Mudd Series, 955 pp., 1937.

Humphreys, W. J., Ways of the weather, a cultural survey of meteorology, 400 pp., The Jaques Cattell Press, Lancaster, Pennsylvania, 1942. (John Hays Hammond Library.)

Jackson, Joseph Henry, Anybody's gold, the story of California's mining towns, 468 pp., D. Appleton-Century Company, Inc., New York and London, 1941. *Illustrated by* E. H. Suydam.

Knibbs, G. H. (editor), Federal handbook prepared in connection with the eighty-fourth meeting of the British Association for the Advancement of Science, held in Australia, August 1914, 598 pp., 1914. (Donated to the library by Eldridge D. Drew.)

Lindahl, Josua (editor), Volume VIII, Plates, Geological Survey of Illinois, 78 plates, 1890. (Donated to the library by Eldridge D. Drew.)

Low, Albert H., Technical methods of ore analysis, 388 pp., John Wiley & Sons, Inc., New York, 1919. (Donated to the library by Eldridge D. Drew).

Rogers, Austin F., and **Kerr, Paul F.,** Thin-section mineralogy, 311 pp., McGraw-Hill Book Company, Inc., New York and London, 1933. (Donated to the library by Eldridge D. Drew.)

Roush, G. A., Strategic mineral supplies, 485 pp., McGraw-Hill Book Company. Inc., New York and London, 1939.

Publications of the Division of Mines

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-three years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for advancing the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

Write for latest revised price list.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
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DIVISION OF MINES
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WALTER W. BRADLEY — State Mineralogist

Vol. 39 — APRIL 1943 — No. 2

CALIFORNIA JOURNAL
OF
MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXIX

STATE DIVISION OF MINES
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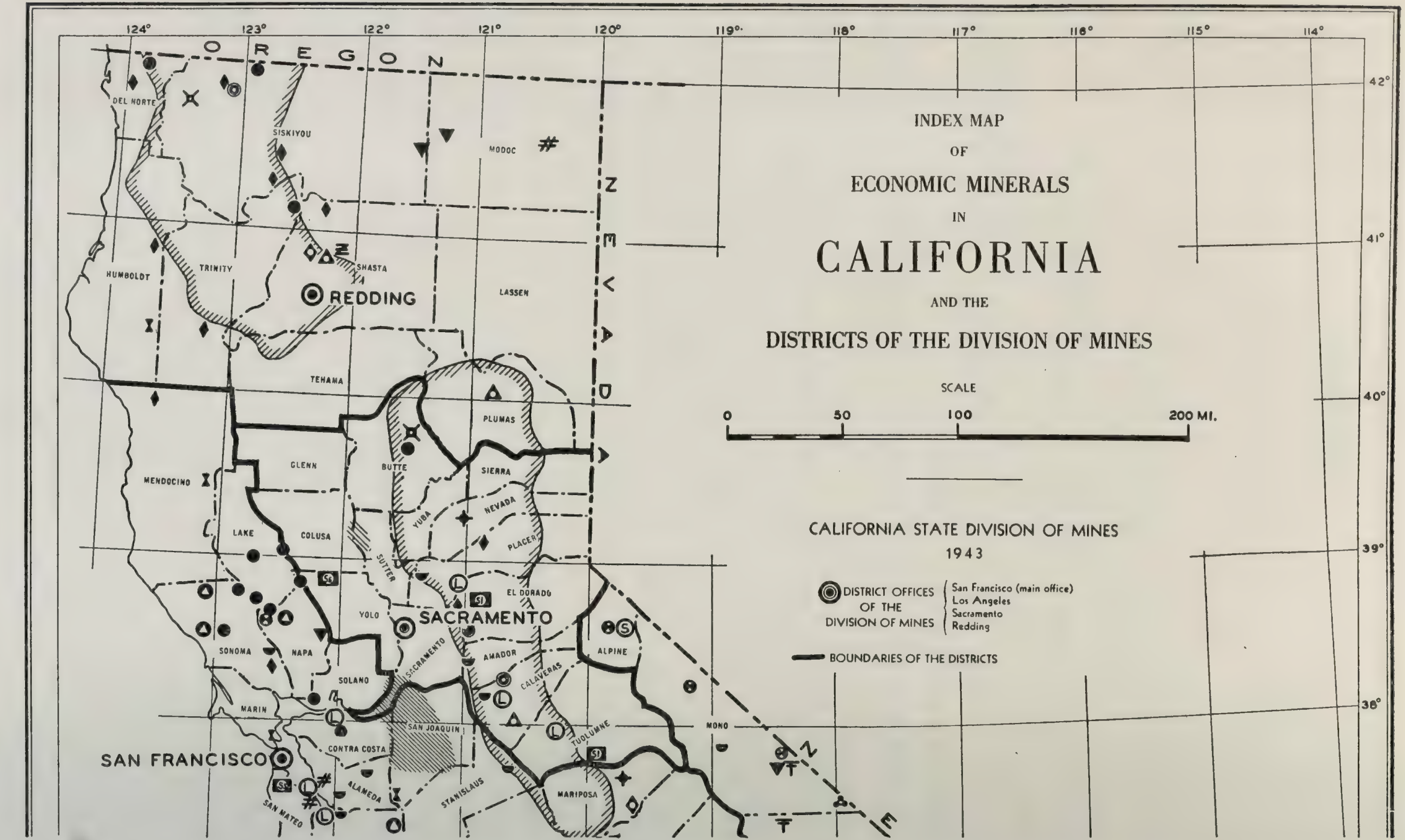
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1943
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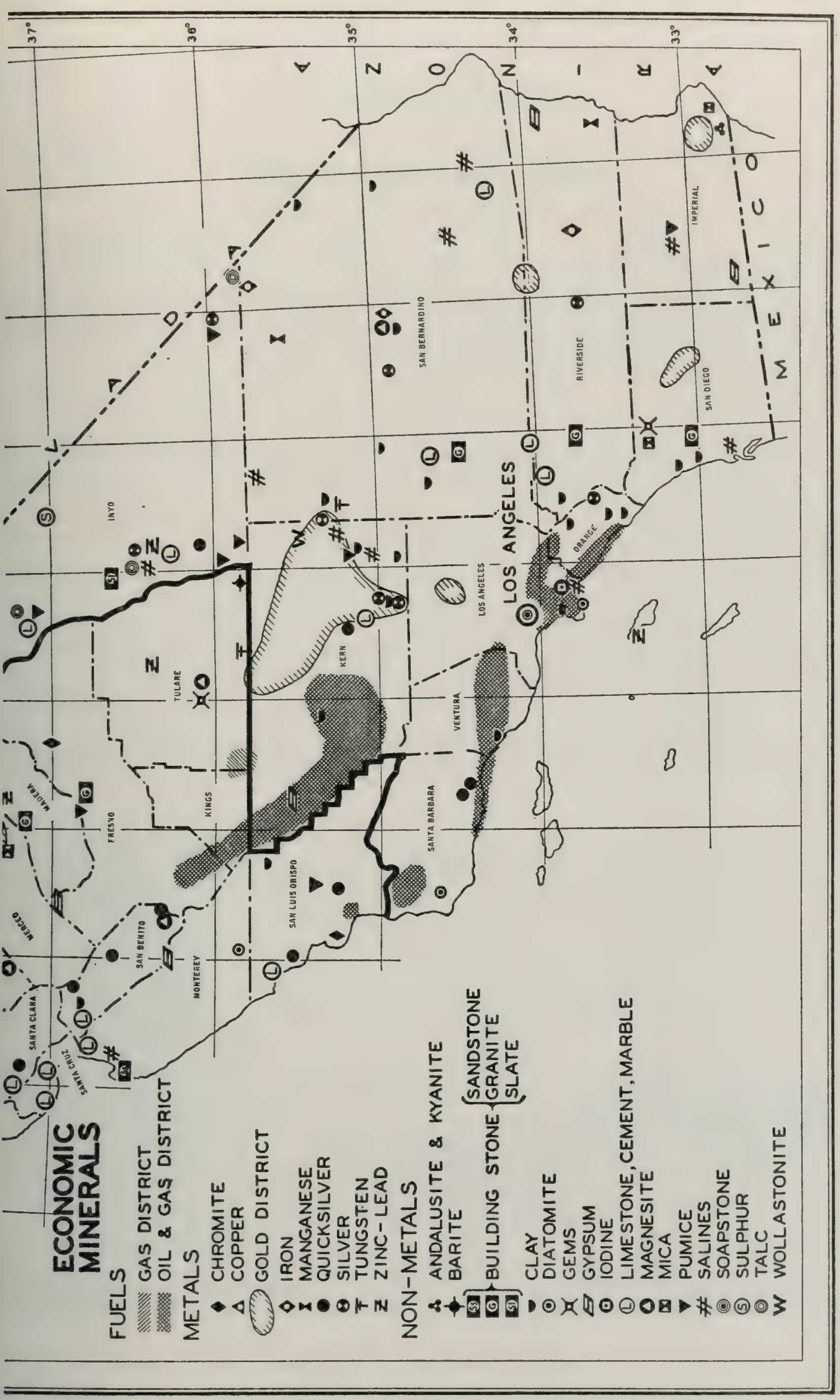
NAPA
SACRAMENTO
AMADOR
CALAVERAS
SOLANO
MARIN
SAN JOAQUIN
MONO
TUOLUMNE
SAN FRANCISCO
CONTRA COSTA
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO


ECONOMIC MINERALS
FUELS
▨ GAS DISTRICT
▩ OIL & GAS DISTRICT
METALS
◆ CHROMITE
△ COPPER
GOLD DISTRICT
◇ IRON
MANGANESE
● QUICKSILVER
SILVER
TUNGSTEN
ZINC-LEAD
NON-METALS
ANDALUSITE & KYANITE
BARITE
Ss SANDSTONE
G GRANITE
Sl SLATE
BUILDING STONE
CLAY
DIATOMITE
GEMS
GYPSUM
IODINE
L LIMESTONE, CEMENT, MARBLE
MAGNESITE
MICA
▼ PUMICE
# SALINES
SOAPSTONE
S SULPHUR
TALC
W WOLLASTONITE
37°
36°
35°
34°
33°
SANTA CLARA
SANTA CRUZ
MERCED
MADERA
SAN BENITO
MONTEREY
FRESNO
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
LOS ANGELES
ORANGE
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
NEVADA
ARIZONA
MEXICO

ADMINISTRATION

ADMINISTRATIVE REPORT

By Walter W. Bradley, State Mineralogist

Personnel

In April, Mr. John G. Bongard, ore-buyers license inspector, took military leave from the Division of Mines and entered war service in the 'Sea Bees' (Construction Battalions, U. S. Navy).

New Publications

Since last noted, the following publications of the Division of Mines have been received from the State Printer and are now available at the offices of the Division:

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

January 1942, being Chapter 1 of State Mineralogist's Report XXXVIII. This chapter contains *Mines and Mineral Resources of Sierra County;* also a special article, *Chromium.* Price 60 cents (plus sales tax in California).

April 1942, being Chapter 2 of State Mineralogist's Report XXXVIII, containing: *Mineral Resources of Imperial County; Geology and Mineral Deposits of the Cargo Muchacho Mountains, Imperial County;* special articles on *Imperial Carbon Dioxide Gas Field, The Legendary 'White Metal' and its 'Ore,' Mine Assessment Work Suspended on Claims within Withdrawn Areas; Summary of 1941 Mineral Production of California.* Price 60 cents (plus sales tax in California).

July and October 1942 (combined), being Chapters 3 and 4 of State Mineralogist's Report XXXVIII and containing: *Hot Springs Deposits of the Coso Mountains; Contact Metamorphic Rocks of the Twin Lakes Region, Fresno County; Tungsten Deposits of the Confidence Mining District, Tuolumne County; Geology of the Welsh Tungsten Deposits, Madera County; Ghost Canyon Tungsten Claims, Madera County; Tabulation of Tungsten Deposits of California to Accompany Economic Mineral Map No. 4* (which is enclosed in pocket; and which is also available for separate sale). Under special articles: *Biennial Report of the State Mineralogist.* This chapter also carries the Index for Volume XXXVIII. Price $1.20 (plus sales tax in California).

BULLETIN 118, GEOLOGIC FORMATIONS AND ECONOMIC DEVELOPMENT OF THE OIL AND GAS FIELDS OF CALIFORNIA. Paper-covered preprints now available, including in pocket, Outline Geologic Map of California, Showing Oil and Gas Fields and Drilled Areas, scale 1:1,000,000. Price $4.00 (plus sales tax in California). The cloth-bound volume will be available at an early date, later, price $6.00 (plus sales tax). The map (Economic Series No. 2) is also available for separate sale, at $1.00 (plus sales tax in California).

SAN FRANCISCO FIELD DISTRICT

MANGANESE DISCOVERY IN SAN MATEO COUNTY

By Henry G. Hubbard*

Redwood Material Company's Quarry. This deposit is at Ralston Avenue, Belmont, between the Bayshore Highway and the Southern Pacific Railroad adjacent to the Coast Highway, in T. 5 S., R. 4 W., M. D. A vein strikes north in the small hill now being quarried for road-building material. The dip is 45° E. and the width is reported to be four feet. The vein extends for a distance of 300 feet along the quarry floor. Much of it is covered by loose dirt.

Considerable silica accompanies the manganese oxides observed in place, but several tons of ore on the dump showed bunches of the high-grade oxides psilomelane and pyrolusite. The hill being quarried and a small area surrounding it consists of typical Franciscan rocks and there is a large tonnage of clay colored by iron oxides. This clay is not strictly an ocherous limonite but it has possible value as a camouflage material.

The quarry is owned in fee by Redwood Material Company, Maple Street, Redwood City, California. President C. B. Stoner contemplates opening the manganese vein formerly exposed in the quarry floor and bulldozing an opencut to a depth of 10 or 15 feet.

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* Junior Mining Engineer, Division of Mines. Manuscript submitted for publication May 14, 1943.

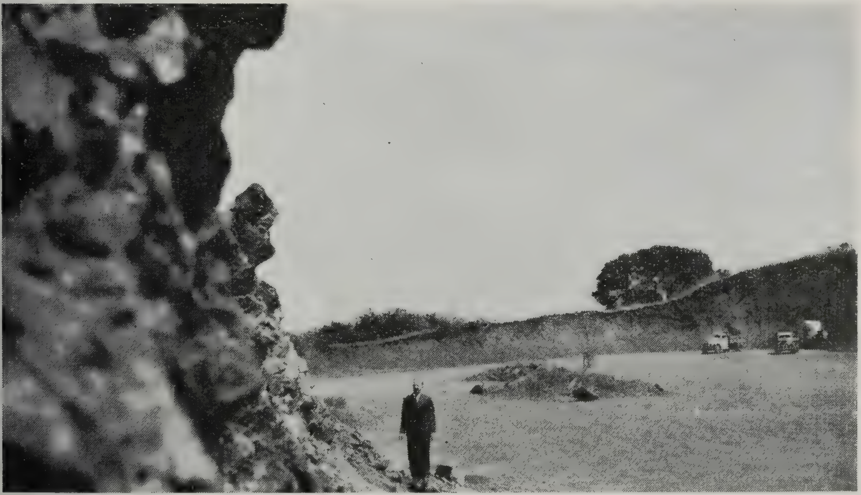

Fig. 1. Low-grade remnant of manganese ore lens at Redwood Material Company's quarry. Some high-grade appears on dump in background.

LOS ANGELES FIELD DISTRICT

CURRENT MINING ACTIVITY IN SOUTHERN CALIFORNIA

By W. B. TUCKER* and R. J. SAMPSON**

OUTLINE OF REPORT

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Riverside County 125
San Bernardino County 126

IMPERIAL COUNTY

Whedon Manganese Mines, Inc. (*Tolbard, Everharty, Tres Amigos Groups*). These mines, comprising 28 claims, are in secs. 18 and 19, T. 11 S., R. 21 E., S. B., 4 miles east of Midway Well. The owner is V. B. Whedon, Bank of America Building, Beverly Hills, California.

These properties have been consolidated by this company which has had them in continuous operation for about a year. Shipments aggregating 45 cars have been made largely to the Phoenix stock pile of the Metals Reserve Company.

Twenty men are working.

Bibl.: State Mineralogist's Reports XXII, pp. 264-266; XXXVIII, p. 130; U. S. G. S. Bull. 710E.

INYO COUNTY

Bishop Tungsten Company. Ralph H. Moore is manager. The company has ceased operations and will probably dispose of its mill at Bishop. This company operated successfully for several years. During this period some 68,000 tons of ore was milled.

Bibl.: State Mineralogist's Reports XXXIV, pp. 462-463; XXXVII, pp. 292-293; U. S. G. S. Bull 640, pp. 229-255.

Imperial Metals, Inc. (*Defiance, Independence,* and *Thompson Mines*). S. B. Mosher, 811 West Seventh Street, Los Angeles, is president. The company is shipping from the Defiance, Independence, and Thompson properties at Darwin.

The 250-ton mill which was completed last year is temporarily shut down pending adjustments designed to increase the recovery of the tungsten in the lead ores. Shipments of 5 to 7 cars per week are being made.

Approximately 35 men are employed.

Bibl.: State Mineralogist's Reports VIII, p. 226; X, p. 211; XV, p. 98; XVII, pp. 287-288; XXII, p. 483, 486, 487; XXXIV, pp. 436-437 and 557-560; XXXVII, pp. 567-568; Reports of Director of the Mint, Precious Metals in U. S., 1883, p. 164; 1884, p. 103; U. S. G. S. Bull. 580, pp. 14-15.

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* District Mining Engineer, Division of Mines.

** Assistant District Mining Engineer, Division of Mines. Manuscript submitted for publication April 16, 1943.

Lakeview Tungsten Mine. The Lakeview mine, comprising 7 claims, is on the south slope of Mount Tom, probably in sec. 27, T. 7 S., R. 30 E., M. D., about 20 miles by road west of Bishop; elevation 10,700 to 11,000 feet. Owners are P. W. Carpenter, George Brown, and W. Bemis Phelps, of Bishop, California. The property is under lease and option to James E. Babcock, 112 West Ninth Street, Los Angeles. G. A. Joslin is consulting engineer.

The country rocks are dolomitic limestone and granite. The ore occurs in tactite which marks the contact of these two formations. The scheelite is disseminated through an epidote-garnet-quartz gangue. The tactite is some 50 feet wide, and has a mineralized core which averages about 12 feet in width. The strike is N. 10° W., the dip 80° W. to vertical. The mineralized zone has been proved on the surface for a length of 125 feet. Samples contain from 1 to 29 percent WO_3; 75 tons of ore milled in Bishop averaged over 4 percent.

Development consists of open cuts and a shaft 50 feet deep. Due to climatic conditions, work has been suspended until the spring of 1943.

Pacific Tungsten Company. E. L. Cord, Beverly Hills, California, is president and owner. The company has been operating the Durham, Fernando, and St. Charles mines at Darwin, and milling the ore in the West Coast Tungsten Company's mill near Keeler.

Operations have been suspended at these properties with the exception of a new shaft which is being sunk on the Fernando.

Bibl.: State Mineralogist's Reports XXII, pp. 484-485; XXXIV, pp. 440, 560-561; XXXVII, pp. 570-571.

The Panaminas Company. George W. Tower, 230 Park Avenue, New York, N. Y. is managing director. The company has a bond and lease on the Adamson tungsten deposit which consists of 8 claims, in sec. 34, T. 6 S., R. 30 E., M. D., in the head of Morgan Creek, about 21 miles west of Bishop and adjoining the Pine Creek mine of the U. S. Vanadium Company on the north; elevation 11,500 feet to 12,800 feet. The owner is Don B. Adamson of Bishop, California. A. H. Heller, 650 South Grand Avenue, Los Angeles, is manager, and Frank Merrilees, Bishop, is superintendent of this operation.

On this property, five roughly parallel veins have been discovered. Each occurs in tactite at the contact of granite and a limestone pendant. The general strike is north, the dip 75° to 80° E., although at and near the surface, the dip is westerly. The veins are known as the Camp vein, Vanadium vein (a continuation of the U. S. Vanadium vein), Middle vein, East vein, and Northwest vein. The East vein is said to be 75 feet wide; for a distance of 200 feet along the outcrop, it carries 2.5 percent WO_3. The Middle vein, about 50 feet west of the East vein, is 15 feet wide, and for a distance of 400 feet carries 1.25 percent WO_3. The Vanadium vein is about 1000 feet west of the Middle vein. The Camp vein is 50 feet farther west. It is 12 to 15 feet wide and contains 1 percent WO_3. The Northwest vein is about 15 feet wide, containing 1 percent WO_3. The gangue is epidote and garnet, through which scheelite is disseminated.

Development work consists of a tunnel on the Camp vein and one being driven under the Northwest vein; also, a crosscut tunnel has been started which will tap both the Middle and East veins. As yet, none of these tunnels have any great length but they are being driven ahead daily.

This company has spent a large sum of money in preparing the property for development and operation. A road has been built to the property and a camp constructed, all units of which are connected by completely covered snowsheds.

Equipment consists of 1500-cubic-foot compressor and a 500-cubic-foot portable machine, bulldozers and snow plows. Four mucking machines are in use in the headings. Storage-battery locomotives are used for haulage. Construction of a jig-back tram 2000 feet long has been started, and the material for a gravity tram one mile long is on the ground. The long tram will terminate at the U. S. Vanadium Company's mine bins. Southern Sierras Company supplies the power.

Ore from development work is going to a stock pile on the property. Seventy-five men are employed.

Bibl.: State Mineralogist's Reports XXXIV, p. 462; XXXVII, pp. 292-293.

Shoshone Mines, Inc. (see also *Tecopa Consolidated Mines*). George W. Nilsson, 555 South Flower Street, Los Angeles, is secretary, and W. Buford Davis, Tecopa, California, president and manager. This company leased the Noonday and Gunsite mines, some 7 miles east of Tecopa, starting its operation in February 1940.

For a description of these properties and history of past operations, the reader is referred to the bibliography given under the Tecopa Consolidated Mines, herein.

The Gunsite-Noonday fissure has been faulted near the south end of the Noonday mine. This fault strikes northeast and has displaced the vein 1200 feet. The present company is working the segment which is 1200 feet southwest of the former Noonday workings, on the Columbia No. 2 claim. Here the vein is 8 to 14 feet wide. The ore shoot is more than 200 feet in length. Gold, silver and lead average better than $25.00 per ton.

New development consists of a shaft sunk on 30° inclination 630 feet, with levels at 165, 265, 365 and 465 feet. Shipments of one car per week are made to the smelter.

Thirty men are employed.

Tecopa Consolidated Mines. Dr. L. D. Godshall, 722 South Oxford Avenue, Los Angeles, is president. The company has leased its Noonday and Gunsite mines to Shoshone Mines, Inc., George W. Nilsson, secretary, 555 South Flower Street, Los Angeles. W. Buford Davis, at Tecopa, is manager.

Bibl.: State Mineralogist's Reports XV, pp. 95-96; 103-104; XVII, pp. 286-287; 291-293; XXII, p. 485; 491-492; 503-504; Rept. of Director of the Mint, Precious Metals in the U. S., 1883, p. 166.

Utacala Group (*Zinc Hill Mine*). The Utacala group comprises 12 claims in the Darwin district on Zinc Hill, 9 miles east of Darwin; elevation 4000 feet. The property has been acquired by Combined Metals Production Company, E. H. Snyder, president, Feldt Building, Salt Lake City, Utah; Guy H. Herbert, Jr., is superintendent.

This company has been developing the property for more than a year and they are now shipping 4 to 5 cars of zinc-sulphide ore per week to their mill at Bauer, Utah.

Bibl.: State Mineralogist's Reports XVII, pp. 294-295; XXII, p. 503; XXIV, p. 458.

KERN COUNTY

Cow Canyon Group. This group of 8 claims is 2½ miles east of Walker's Pass Road and about 3 miles from Dee's Service Station, probably in sec. 12, T 25 S., R. 36 E., M. D.; owners are A. N. Houser, of Weldon, California, W. P. Lewis, of Trona, California, and W. J. Betty, of Inyokern, California. The property was leased to H. V. Hughes.

The lessee had a crew of 14 men trenching the tactite outcrops for 30 days, at the end of which time he relinquished the property.

F. O. B. Tungsten Group. This group of 22 claims is on the west side of Indian Wells Canyon, 5½ miles west of the Owens Valley highway and approximately the same distance from the Homestead Service Station, which is 19 miles south of Little Lake; elevation is about 5000 feet. Owners are Grant P. Merrill, Mojave, California, and A. L. Crowthers, Bishop, California. This property is leased to Erle P. Halliburton, 1709 West Eighth Street, Los Angeles.

The county rock, as indicated by very limited outcrops, consists of gneissoid granite and crystalline limestone. The limestone appears to have a thickness of 100 feet or less. The contacts are marked by silicate zones, consisting largely of epidote and garnet. These zones are as much as 12 feet in width and probably average about 6 feet. They are traceable along the mountainside for nearly 1200 feet. There are two parallel veins striking northwest and dipping steeply to the east. Each occurs on the limestone side of the silicate zone and the scheelite is associated with a light-pink garnet. This pink garnet occurs only in very small crystals, whereas some of the associated scheelite crystals are more than an inch across. A northeast-trending fault has displaced the veins approximately 150 feet at a point about 300 feet from the northwest end of the deposits. It is reported that samples from the outcrop run from 2½ percent to 12 percent, averaging 3 percent.

The lessee is trenching this hillside to determine the extent of the deposit.

Equipment consists of portable compressor and jackhammers. Four to six men are working.

Hi-Peak Tungsten Group. The 14 claims of this group are on the east slope of the Sierra Nevada, about 19 miles south of Little Lake and one mile west of the Owens Valley highway, in sec. 10, T. 26 S., R. 28 E., M. D. Owners are Emery V. Bales and H. U. Gifford. The property is leased to U. S. Flare Corporation, J. M. Hoyt, Jr., president, 9730 Wilshire Boulevard, Beverly Hills, California, and Norman Whitmore, consulting engineer, Subway Terminal Building, Los Angeles.

The country rocks are granite and crystalline limestone. The limestone apparently has been intruded by a series of narrow, granitic dikes which are now schistose. The veins, of which some 6 or 8 have been found on the property, occur at or near the contacts, striking north and dipping about 70° E. As now exposed, they are from 5 to 8 feet, between walls. The vein filling is largely altered wall rock but on one or both walls there is usually a streak 6 to 8 inches, principally epidote, which is plentifully sprinkled with scheelite. Scheelite is sparsely disseminated throughout the adjoining 2 feet. This scheelite fluoresces a golden color, but it is said that the molybdenum content is low.

Development consists of two tunnels. The upper tunnel driven southwest 280 feet, was in granite for about 120 feet, then passed into alternations of tactite and granitic schist without encountering ore. About 100 feet below and several hundred feet north, another crosscut tunnel has been driven west 300 feet. While most of the rock in this tunnel is limestone, there are narrow, granite-schist dikes at infrequent intervals. Three veins have been encountered in the lower tunnel; the first at 92 feet, the second at 134 feet, and the third at 198 feet from the portal. The walls of the first and third are limestone and schist but the second vein appears to be wholly in limestone. Drifts have been driven on these veins as follows: first, north 60 feet, raise 25 feet; second, south 100 feet, raise 33 feet; third, north 18 feet. The 250 tons of ore shipped from these workings are said to have averaged about 1 percent WO_3.

Equipment consists of 115-cubic-foot and 210-cubic-foot compressors. Six men and D. B. Christison, superintendent, are employed.

Rand Gold Dredging Associates. Newton Cleaveland, Capt. Norman Cleaveland, Mayville C. Milton, and F. P. Adams, of 315 Montgomery Street, San Francisco, have leased 1000 acres about 2 miles west of Randsburg from various owners. M. E. Powers is in charge of operations on the ground.

A 3½-cubic-foot, 3000-yard-capacity bucket dredge has been moved onto this ground from the property of the Roaring River Gold Dredging Company in Shasta County. It is estimated that there are 5,000,000 yards, having an average depth of 45 feet, and an average overburden of 10 feet. The dredge will dig to 60 feet. Both gold and scheelite are recovered.

Some difficulty was experienced in securing sufficient water from four wells drilled by the operators. This has been overcome through an arrangement for an ample supply from the Goler wells of the Yellow Aster Mining Company.

Tungsten Hill Mine. This mine, comprising 12 claims, is located in sec. 3, T. 28 S., R. 32 E., M. D., 1½ miles northwest of Havilah. Owners are T. M. Smith and E. E. Lambert of Havilah, California.

One hundred tons of ore from this property has recently been treated in the Basin View mill near Bodfish. Formerly some shipments were made to the mill at Weldon. Two men are working.

Bibl.: State Mineralogist's Report XXXVII, p. 579.

ORANGE COUNTY

Blue Light Mine (Silverado). This lead-zinc-silver mine comprises 13 claims consisting of 269 acres, 60 acres of which are patented, situated in Silverado Canyon, in the Cleveland National Forest Reserve, in secs. 11 and 14, T. 5 S., R. 7 W., S. B., 20 miles east of Orange; elevation 2650 to 3050 feet. The owner is Blue Light Silver Mines Company, C. S. Chapman, president, John J. Dwyer, vice president, Sam L. Collins, secretary-treasurer, and W. A. Young, manager, Fullerton, California.

The company has secured a development loan of $20,000 from the Reconstruction Finance Corporation for the purpose of shipping lead-zinc ore. The property produced from 1935 to 1941, during which period ores carrying high lead value were shipped, leaving a substantial tonnage of zinc ore that under present metal prices can be shipped at a profit.

Two parallel lodes known as the Blue Light lode and the Dike vein occur in the metamorphic rocks. The Blue Light vein has been the most productive and has been extensively developed along its outcrop for a considerable distance. This vein has a width of 2 feet to 6 feet. The ore is silver-bearing galena, associated with zincblende and pyrite. Seven known orebodies have been developed on the Blue Light lode. The Blue Light vein strikes N. 16° E. and dips 30° to 40° E. The vein, developed by seven tunnels, has an average width of 4 feet. At an elevation of 3000 feet, No. 2 tunnel has been driven south on the vein 350 feet. No. 3 tunnel, which is 50 feet in elevation below No. 2 tunnel, is a crosscut 200 feet to the vein, then drift south 470 feet on the vein. No. 4 tunnel level is located on south workings at an elevation of 2700 feet. A crosscut tunnel, driven east 700 feet at 400 feet from portal, cuts the vein. No. 5 tunnel at an elevation of 2764 feet was driven south on the vein for 1200 feet. There is a raise from No. 5 tunnel level in ore to No. 3 tunnel level. The orebody developed is 4 to 6 feet in width, and is reported to assay 0.25 ounces in gold, 25 to 50 ounces in silver, 3 percent lead, with 10 percent zinc. Orebody is developed 60 to 100 feet in length; average width 4 feet. No. 7 tunnel, which is in Pine Canyon at an elevation of 2460 feet, is driven 1200 feet south on Blue Light vein. The No. 7 tunnel level is 300 feet in elevation below No. 5 level. At 1200 feet from the portal, an incline raise is being driven to connect with crosscut from No. 5 tunnel level. The raise is now up 60 feet. Three short shoots of ore have been developed on No. 7 tunnel level. The ore extracted is reported to assay 0.06 ounces in gold, 12 to 20 ounces in silver, 4 percent in lead, and 13 percent in zinc.

Mine equipment consists of Clayton compressor, 14 by 8 by 8 inches, driven by Fairbanks-Morse gas engine; Sullivan portable compressor, capacity 300 cubic feet; Ingersoll-Rand portable compressor, capacity 110 cubic feet; jackhammers; stopers; and blacksmith shop.

Mill equipment consists of flotation plant, with a capacity of 50 tons. Mill is driven by 100-horsepower Fairbanks-Morse semidiesel gas engine. Six men are employed on development.

Bibl.: State Mineralogist's Reports XX, pp. 43-45; XXI, pp. 63-64.

Ortego Mine (*Old Dominion*). This lead-zinc property comprises 640 acres of patented land located in sec. 7, T. 6 S., R. 5 W., S. B., on the ridge west of Long Canyon, in the Cleveland National Forest Reserve, 6 miles west of Elsinore, a station on the Santa Fe Railroad; elevation 3000 feet. Owners are V. B. Anderson and Earl Frevert, 117 Spurgeon Street, Santa Ana, California. The property is operated under the name of Ortego Mining Company, Santa Ana, California.

The Old Dominion vein is in metamorphic rocks, near the contact of granite to the east. The formation in which the vein occurs is a crystalline rock that varies from a dark-brown felsite to a finely banded quartzose rock. The Old Dominion vein strikes N. 20° W., dips 45° E.; has a width of 6 to 8 feet, and an 18-inch streak of high-grade lead-zinc ore on the hanging wall. The vein material is heavily mineralized with pyrite and carries gold and silver, associated with galena and sphalerite. Analysis of the ore, made by Smith-Emery Company, shows 50 percent pyrite, 30 percent calcite, 13 percent limonite, 5 percent quartz and 2 percent siderite. The vein can be followed on the surface for a distance of 300 feet to the north where it has been displaced by a fault. Strike of fault is north, the dip 35° W.

Development consists of incline shaft sunk on the vein to a depth of 60 feet in Long Canyon. North of shaft 80 feet, a crosscut tunnel has been driven west 500 feet; at a point 40 feet west of the portal, it intersected the vein, then continued into the footwall of the vein for 460 feet. A drift driven north 100 feet intersects a winze from the upper tunnel level. At a point 200 feet north of incline shaft, a tunnel is driven northwest 50 feet to fault; drift south along fault 75 feet to shaft sunk on the vein to a depth of 45 feet, where the vein is cut off by a northward-trending fault. At this point a winze is sunk on the fault, which has a dip of 35° W., to a depth of 35 feet. There is a drift north 120 feet along fault 120 feet from crosscut tunnel. In the latter part of 1942, 100 tons was mined from incline shaft and shipped to United States Smelting, Refining & Mining Company, Midvale, Utah. Shipments assayed gold 0.02 ounces, silver 25.8 ounces, copper 0.3 percent, lead 3.5 percent, zinc 3.1 percent, iron 21 percent; total value per ton, $13.63. Sample of 15 tons of selected ore in ore bins was reported to assay gold 0.03 ounces, silver 45.2 ounces, lead 8.7 percent, zinc 9.11 percent.

Equipment consists of 12-horsepower gasoline hoist, one drill compressor, air drills, and blacksmith shop.

Mill equipment consists of two 6- by 8-inch jaw crushers; 3- by 3-foot ball mill; 4 home-made flotation cells. Capacity of mill is 10 tons per 24 hours. Three men employed sinking incline shaft to a depth of 100 feet.

Wilhunt Lead-Silver Mines (*Morrow*). These mines comprise 5 claims situated in Santiago Canyon, in sec. 27, T. 5 S., R. 6 W., S. B., 9 miles northeast of El Toro; elevation 2600 feet. The owner is L. W. Hunter, 3482 San Marino Street, Los Angeles. The claims were relocated by L. W. Hunter as Wilhunt group in 1942. The property was operated from 1896 to 1897 by the Santiago Mining Company, Orange, California. This company mined and shipped ore reported to carry 40 ounces in silver, 24 percent lead, and 10 percent zinc. The property was owned and operated by W. S. Morrow, Orange, California, from 1916 to 1935. From 1916 to 1925, W. S. Morrow made some small shipments of selected ore to U. S. Smelting, Refining & Mining Company's smelter, Midvale, Utah. In the latter part of 1942, L. W. Hunter received a preliminary development loan from the Reconstruction Finance Corporation for $5000.

The vein strikes north, dips 35° E., and is 3 feet wide. It is in slates and quartzites along contact with diorite. The ore is galena and lead carbonate, associated with sphalerite and pyrite. Samples cut in upper tunnel and shipped to U. S. Smelting, Refining & Mining Company's smelter Midvale, Utah, assayed 0.02 ounces in gold, 35.8 ounces in silver, 23.6 percent lead and 10 percent zinc. Developed by three tunnels. Upper tunnel is driven as crosscut 210 feet to vein, then drift south 100 feet on the vein. Ore shoot developed was 50 feet in length and stoped to surface. Winze on ore 30 feet below tunnel level. About 40 feet in elevation below upper tunnel, an intermediate tunnel has been driven N. 45° E. for 120 feet, then north on vein 20 feet. At 120 feet from the portal, a raise has been driven 30 feet but this raise does not connect with workings from upper tunnel level. At an elevation 130 feet below No. 2, or intermediate tunnel, a lower tunnel is driven N. 45° E. for 175 feet as crosscut to intersect vein developed in upper workings. Six men employed in retimbering workings in upper tunnel and also lower tunnel level.

When road to the property is completed, they plan to install compressor and flotation plant, with a capacity of 10 tons per 24 hours.

Bibl.: State Mineralogist's Reports XV, p. 516; XXI, p. 64.

RIVERSIDE COUNTY

Pawnee Mine (Carr Mine). This property comprises 4 claims in sec. 31, T. 8 S., R. 3 E., S. B., on the south slope of Beauty Mountains, 6 miles northeast of Oak Grove and 9 miles from Aguanga; elevation 4000 feet. Owners are Emerson L. Carr and William Carr, Aguanga, California. The mine is under lease to Riverside Tungsten Company, J. W. Harris, 711 Lasbrook Avenue, El Monte, California, and J. L. Richardson, 3900 Market Street, Riverside, California.

The present lessees have unwatered and cleaned out the underground workings on this property with money borrowed from the Reconstruction Finance Corporation.

Bibl.: State Mineralogist's Reports XXXVI, p. 48; XXXVII, pp. 583-584.

Phoenix Tungsten Property. This property, comprising 640 acres of patented land, is on the southeast slope of the San Jacinto Mountains, in Andreas and Murray canyons, in sec. 9, T. 4 S., R. 4 E., S. B., about 7 miles southwest of Palm Springs; elevation 1500 to 2800 feet. Owners are Andreas Canyon Club, Inc., of Palm Springs, California, who have leased to Jas. R. Maynard and Henry B. Tuttle, 135 Palo Verde Street, Palm Springs, California.

The scheelite has been found in the ridge between Andreas and Murray canyons. This ridge, which rises about 1000 feet above the bottom of each canyon, is extremely precipitous on the Andreas Canyon side. The country rock consists of granite, limestone, and some mica schist. The limestone occurs as thin, short remnants, largely altered to epidote and garnet. The strike is northeast, dip 45° SE. The sporadic outcrops of tactite in which the scheelite occurs may be 18 feet in width, and they are rarely longer. In a distance of about 900 feet along the ridge there are eight of these outcrops. Each contains at least two spots from 3 to 6 feet in width, which carry good tungsten values; but the length exposed on the surface in any of these is not sufficient to constitute a commercial ore shoot. The lessees propose to open several of these in the hope that they may be able to develop enough ore to support a small mill. They have built 3 miles of steep trail and are now taking in (by man-power) a 120-cubic-foot portable compressor.

Four men are working.

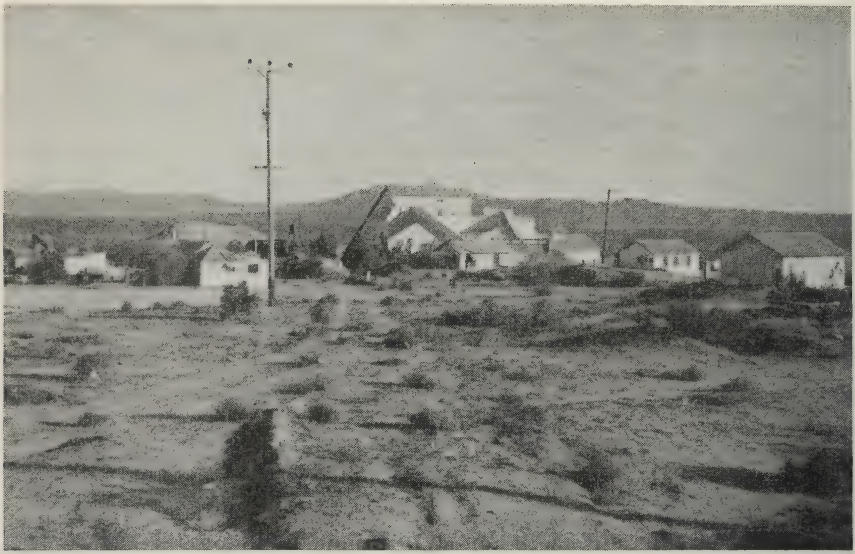

FIG. 1. Mill of Atolia Mining Company, Atolia, San Bernardino County.
Photograph by Walter W. Bradley.

SAN BERNARDINO COUNTY

Atolia Mining Company. This company (1022 Crocker Building, San Francisco) has temporarily shut down the flotation section of its tungsten mill at Atolia while installing pumps to deliver an additional 20,000 tons from another tailings pile. The gravity section of this mill is running on ores from the Amity, Union, and Papoose mines, and from ten sets of leasers working at various places on the company's property. To keep this section of the mill up to its capacity of 250 to 300 tons per day, the table sands from the Union mill are being hauled to this plant.

Bibl.: State Mineralogist's Reports XV, pp. 830-839; XVII, pp. 370-372; XX, pp. 96-97; XXVII, pp. 365-366; Bull. 95, pp. 70-78 and 125-128.

Bagdad-Chase Mine (*Pacific Mines*). The property comprises 17 patented claims totaling 340 acres. It is situated in the Stedman mining district, in secs. 5 and 6, T. 6 N., R. 8 E., S. B., 7 miles south of Ludlow. Owner is John H. Hobbs, Glendora, California. The mine is under lease to Frank Royer, Red Mountain P. O., San Bernardino County, California, and Don L. Love, Ludlow, California.

The ore is deposited in an igneous breccia on a contact of monzonite and rhyolite. The brecciated material, which is the result of faulting, consists of both rhyolite and monzonite fragments cemented with highly siliceous material. Strike of the mineralized zone is east, and dips are 25° to 30° N. The average width ranges from 8 to 20 feet. The ore is very siliceous, being heavily stained with iron oxides and some copper oxides and silicates.

Development consists of three shafts, a vertical shaft 400 feet deep, another vertical shaft 125 feet deep, and an incline shaft 450 feet deep. Present operations are confined to shaft east of the main vertical shaft, from 90-foot level to surface glory hole. The present operators developed ore in the footwall of the vein originally worked by former operators on the 60- and 90-foot levels. The orebody being stoped from these levels to the glory hole is 300 feet in length, 18 feet in width.

Since the early part of 1940, the shipments to American Smelting & Refining Company's smelter at Hayden, Arizona, have been 40,000 tons of siliceous gold ore, stated to carry gold $9.30 per ton, copper 0.80 percent, and silica 80 percent. At present, 100 tons of ore per week is being shipped.

Mine equipment consists of 25-horsepower gasoline hoist; one Ingersoll-Rand compressor, capacity 320 cubic feet; one Worthington portable compressor, capacity 320 cubic feet; air drills and 5-ton dump truck. Seven to 14 men are employed.

Bibl.: State Mineralogist's Reports XV, p. 790; XVII, pp. 341-342; XXVII, pp. 278-279; XXXVI, pp. 56-57; 232-233.

Black Jack Iron Mine. This mine comprises 10 claims known as Black Jack group, situated in the Bristol Mountains in sec. 24, T. 6 N., R. 12 E., S. B., 6 miles northeast of Amboy; elevation 2000 to 5000 feet. Owner is J. W. Gray of Siberia, California. The property is under option to Moharvey Minerals Corporation, Paul Hansen, president, William Duggan, secretary, and James O. H. Keyser, superintendent; offices, 257 South First Street, San Jose, California.

The iron deposit consists of five outcrops of magnetite occurring in dolomite near the contact of granitic rocks. The general strike is north, dip 50° E. These outcrops of magnetite occur in an area 200 feet in length by 100 feet in width, on the Black Jack No. 1 claim. Sufficient development work has not been done on the individual outcrops to make an estimate of tonnage. The outcrops of iron are 10 to 25 feet wide, 30 to 65 feet long, and are exposed for 20 feet above the dolomite. The ore is magnetite, assaying 57 percent iron, 2.7 percent silica, and 0.5 percent sulphur.

Equipment consists of Rix compressor, capacity 320 cubic feet; jackhammers; tractor; bulldozer and trucks.

Ten men are employed building camp at an elevation of 1900 feet and constructing a road from camp to the deposit at an elevation of 2500 feet. The company has applied to the Reconstruction Finance Corporation for a development loan.

Carbonate King Zinc Mine. This mine comprises 14 claims known as Crystal Cave group, situated on the western slope of Kokoweef Peak, in the Ivanpah Mountains, in the N½ sec. 4, T. 15 N., R. 14 E. and the S½ sec. 32, T. 16 N., R. 14 E., S. B., 5 miles southeast of Mountain Pass and 14 miles north of Cima, a station on the Union Pacific Railroad; elevation 5000 feet. Owner is L. P. Ressler, Mountain Pass, California. The property is under option to Crystal Cave Mining Company, H. C. Moore, president, Herman Wallace, secretary, 3352 Isabel Drive, Los Angeles.

The company is a Nevada corporation, with offices at Las Vegas, Nevada; under lease to W. F. Huston, Mountain Pass, via Nipton, California. Crystal Cave group was located by L. P. Ressler in 1928 but it was not until 1941 that zinc ore was discovered on the property by W. F. Huston, who had a contract to drive a crosscut tunnel to intersect the Kokoweef Cave for the Crystal Cave Mining Company.

The orebody occurs along a fracture or fractures in dolomitic limestone which strikes north, dips 60° W. and is 10 to 12 feet wide. The ore is sphalerite near surface which has been oxidized to form hydrozincite and smithsonite, associated with hematite and some cerussite (lead carbonate).

Development consists of single-compartment shaft sunk on an inclination of 70° to a depth of 120 feet, with levels at 50, 90 and 120 feet. On the 50-foot level, drift 55 feet north in ore; on 90-foot level, drift 130 feet north in ore; on 120-foot level, crosscut west to orebody.

Ore mined and shipped to Ozark Mining & Smelting Company, Coffeeville, Kansas, to December 1942, was about 2000 tons, of 38 to 40 percent zinc with some lead, gold, and silver.

Analysis of Ore Shipments

Zinc	38.0%
Lead	1.1%
Iron	4.2%
Silver	10.3 oz.
Gold	trace
Insol.	12.0%
Lime (CaO)	12.0%
H_2O	5.2%

They are now hauling 10 tons per day to government stock pile at Jean, Nevada.

Mine equipment consists of 6-horsepower gasoline hoist; 130-cubic-foot compressor and jackhammers; aerial tramway 1100 feet in length from shaft to loading bins. Eight men are employed.

Colosseum Mine. This mine comprises 2 patented claims (Colosseum No. 1 and Colosseum No. 2), and 32 claims held by location, situated on the northwest slope of Clark Mountains, in sec. 19, T. 17 N., R. 13 and 14 E., S. B., 10 miles north of Valley Wells and 23 miles north of Windmill Station, on U. S. Highway 91; elevation 5500 to 6100 feet. Owner is the Colosseum Mining & Smelting Corporation, C. W. Gowman, president, Earl Thomas, secretary, 7371 West Sunset Boulevard, Hollywood, California. The property was under option to Harold Chase and Walter Lineberger, of Santa Barbara, California, from February 1938 to November 1942.

During this period, 5000 feet of diamond-drill work was done to determine the extent of orebodies; also development on lower tunnel level on No. 2 orebody. These parties suspended operations in the latter part of 1942, surrendering their option.

In the immediate vicinity of the Colosseum mine there is a great anticlinal fold of thick beds of stratified rocks, consisting of sandstone, limestone, dolomite, and thin-bedded shales. These rest upon gneissoid granite. Into this formation, there has been thrust a large, dome-shaped mass of quartz monzonite. Probably following the granite replacement, an intrusion of rhyolite porphyry occurred, in a general N. 30° E. direction. Subsequent to the intrusion of the rhyolite, intensive fracturing occurred in the rhyolite plug, with minor faulting. The major fracture strikes N. 20° W. to N. 20° E. A general mineralization of the rhyolite plug exists along intersecting fractures, metallic minerals being pyrite and chalcopyrite. The pyrite is auriferous. There are two types of ore deposits. The first, No. 1 orebody, is a mineralized network of intersecting fractures within the highly altered rhyolite plug. The second, No. 2 orebody, is a contact deposit on contact of granite and rhyolite plug. The orebodies strike N. 60° E. and dip 80° SW. Estimated tonnage of ore developed in the two orebodies is reported to be 116,000 tons with an average value of $8 per ton in gold.

Since the Twenty-seventh Report of the State Mineralogist was issued (1931), the following development work has been done on the property:

At an elevation of 5700 feet, and 177 feet in elevation below upper tunnel, a lower tunnel has been driven N. 20° E. for 440 feet in granite, intersecting shaft at a depth of 200 feet; at 400 feet from the portal, it intersected a contact of granite and rhyolite porphyry. At 435 feet from the portal, a crosscut was run northwest 160 feet to west contact of No. 2 orebody, then drift along contact 160 feet in ore. The orebody developed along contact is 100 feet in length by 12 feet in width. Average value is reported to be $7.85 per ton. Upper tunnel is 800 feet in length; elevation 5877 feet. Upper tunnel level and intermediate tunnel level have developed No. 1 orebody which is 125 feet in length and 60 feet in width. Total amount of development is about 4000 feet.

Mine equipment consists of one 180-horsepower Fairbanks-Morse diesel engine; one 60 K.V.A. Fairbanks-Morse, 3-phase, 60-cycle, 460-volt generator; one 20-horsepower Westinghouse generator; one Ingersoll-Rand 2-stage (12- by 12-inch) (7½- by 12-inch) air compressor; one Sullivan drill sharpener; mine cars and air drills.

Mill equipment consists of concentration mill with a capacity of 50 tons per 24 hours; one 100-ton ore bin; one 3D Gates gyratory crusher; one Challendge ore feeder; one 24-foot bucket elevator; one 36- by 96-inch vibrating screen; one 5- by 4-foot Marcy type of ball mill; one 50-horsepower Westinghouse motor; one 18- by 48-inch trommel; one Cone classifier; 2 Wilfley tables; one 25-horsepower motor; 2 Groch flotation cells; one 12-foot rake classifier; one 16-foot conical settler; one 20-foot Dorr thickener; three 8-foot wood storage tanks; one 20- by 20- by 8-foot concrete water-storage tank, with a capacity of 35,000 gallons.

From well on Mojave tungsten claim, water is pumped through 5000 feet of 2-inch pipe line to water storage tank above mill. Previous to 1938, the mill was operated and produced 1000 tons of concentrates reported to have a value of $20 to $40 per ton in gold. Idle.

Bibl.: State Mineralogist's Reports XX, pp. 92-93; XXVII, pp. 291-292.

Dale Lake Sodium Sulphate Deposit. This deposit comprises nine 160-acre placer claims totaling 1440 acres, situated in secs. 26, 27, 34, and 35, T. 1 N., R. 12 E., S. B., 17 miles east of Twenty-nine Palms and 30 miles south of Amboy, a station on the Santa Fe Railroad; elevation 1180 feet. Owner is Chemical Mines Company, J. E. Bush, president, C. H. Hobson, secretary, 1204 West 31st Street, Los Angeles. The property was acquired under lease in March 1939 by the Desert Chemical Company, L. F. Foran, president, Lee Richardson, secretary and manager, 4031 Goodwin Avenue, Glendale, California.

The brines of the lake contain 22 percent sodium chloride and 7 percent sodium sulphate at a temperature of 70° F. Seven wells about 150 feet apart near the center of the lake have been drilled to depths of 150 feet. The brine from these wells is pumped to four 7-acre crystallizing vats or spray ponds. The central pumping plant is located at the junction of the four crystallizing vats, with an intake from each vat. Spraying is under operation during the winter months for the recovery of mirabilite, glauber salt, hydrous sodium sulphate, $Na_2SO_4.10\,H_2O$. The sodium sulphate is separated from the solution by evaporation, or by chilling a saturated solution below 33° C. The concentrated solution from crystallizing vats is pumped by 15-horsepower electric-driven turbine pumps to two 5-acre finishing vats where sodium sulphate separates from the brine as glauber salt. The sodium chloride from the vats is pumped to one 80-acre vat from which it flows to four 5-acre vats for evaporation and recovery of NaCl. Sodium sulphate is harvested during dry summer months. Production started January 1940, and yearly production of sodium sulphate amounted to 15,000 tons. On the southwest end of the lake, there is a bedded deposit of thenardite (Na_2SO_4), anhydrous sodium sulphate, 600 feet in width and 4000 feet in length, average thickness 6 feet, with 6 to 8 feet of overburden. The overburden is stripped off and thenardite mined and hauled by truck to central washing plant where clay and sand are washed out. Thenardite is reported to carry 94 percent sodium sulphate. They are at present shipping 100 tons per day. The sodium sulphate is hauled by diesel trucks having a capacity of 30 tons each, to Amboy. Sodium chloride is shipped to Basic Magnesium Company, Las Vegas, Nevada.

The thenardite is dumped from trucks into 50-ton ore bin, then to roll-type crusher, where it is crushed to $\frac{1}{8}$-inch size and conveyed by 36-inch belt conveyor to two 100-ton circular wooden bins. From bins, it is loaded into box cars for shipment to pulp plants. Crystallized sodium sulphate also goes to circular bins for shipment.

Two fresh-water wells 400 feet in depth are located one mile west of the plant and water for plant and camp is pumped by Pomona turbine pumps, each driven by a 15-horsepower motor. Electric power plant consists of 300-horsepower 4-cylinder Fairbanks-Morse diesel engine, direct-connected, with 170 K. V. A. generator to furnish electric power for pumps and lights for camp. Twenty men are employed.

Desert Tungsten, Inc. W. De Witt of Randsburg, California, is president of the company, which has a lease from the Monarch Rand Mining Company on a portion of Baltic Gulch, about 2 miles southeast of Randsburg.

The overburden here will probably be from 6 to 12 feet thick. It will be stripped and the pay dirt moved by a carryall type of scraper. From a hopper, 2- to 3-yard capacity, by a belt conveyor to 2 sets of undershot riffles, each about 12 feet long, the undersize going to 4 riffled cylinders, tails to dewatering box. Capacity is about 50 tons per day. Gas engines supply power. Water comes from the Little Butte mine in Randsburg. Three men are working, setting up the plant.

Evening Star Mine (Bernice Group). This tin property, consisting of 4 claims, is on the north slope of the Ivanpah Mountains, about 9 miles north of Cima and 10 miles southeast of Valley Wells. Owners are Vaughn Maynard and Hiram Whisler, Santa Ana, California.

Property is under lease to C. F. Wendrick, Steel Service & Sales Company, Chicago, Illinois.

The country rock is a dolomitic crystalline limestone. There are granitic outcrops to the south of the deposit. The limestone is traversed by two intersecting fissure veins making an angle of about 40° with each other, the strike being N. 70° W. and S. 70° W. The northwest vein is practically vertical; the southwest vein dips to the northwest. These veins range from 2 to possibly 10 feet in width. The calcite, with subordinate tremolite gangue, carries cassiterite.

Development consists of a shaft sunk at the intersection of the two veins, vertical for about 35 feet and then inclined at 45° to the west for about 70 feet. The highly iron-stained vein is as much as 10 feet wide and is said to carry 2 percent tin. About 100 feet to the north, a shaft 30 feet deep has been put down on the vertical vein. The vein is about 4½ feet wide here. Crystals of cassiterite may be readily identified in this material. Some of the vein matter shows distinct fluorine stains and carries a little chalcopyrite. Trenching between the two shafts indicates that the vein is continuous.

A shipment of 25 tons to the Tin Processing Corporation, Texas City, Texas, in 1942, ran 6.27 percent tin. The operators are building a small mill some 10 miles north of the mine. It is about half a mile east of Valley Wells and about 200 yards south of Las Vegas highway. Four men are working.

Excelsior Talc Mine. This mine, comprising 13 claims, is on the southeast slope of the Kingston Mountains, 28 miles north of Valley Wells and about 30 miles southeast of Tecopa. The owner is Southern California Minerals Company, 320 South Mission Road, Los Angeles.

The talc bed occurs between a dolomitic hanging wall and a serpentine footwall. Strike is N. 45° W., dip 45° SE. Width is 15 to 50 feet, average being about 20. The talc is white and the lime content is low. It has been developed by tunnels. Upper tunnel has been driven northwest 800 feet. The lower tunnel, 165 feet on the dip below upper tunnel, has been driven northwest 1000 feet. At 450 feet from the portal, there is a winze 110 feet deep with levels at 50 feet and the bottom.

The owners have been shipping since 1936. Shipments aggregate about 10,000 tons. At present they are shipping 100 tons per month. The material is loaded at Dunn Siding about half way between Yermo and Kelso on the Union Pacific Railroad.

Equipment consists of 105-cubic-foot compressor and air tugger, at winze.

This company had to build 21 miles of road to make the property accessible. Three men are working.

Iron Horse Mine (formerly *Jack Rabbit*). This lead-silver property, comprising 2 claims, is in the Clark Mountain mining district, in sec. 29 (?), T. 16 N., R. 15 E., S. B., 18 miles north of Cima and 5 miles south of Wheaton Springs; elevation 5000 feet. Owner is Tony Marteletti, of Las Vegas, Nevada. The mine is under lease and bond to Malcolm L. Huckleberry, c/o Basic Magnesium Company, Las Vegas, Nevada, and Foster Dawson, 819 North Eleventh Street, Las Vegas, Nevada.

The country rock is limestone, into which has been intruded a granitic dike. The vein occurs in a fissure in the limestone a short distance from the dike. The strike is N. 20° W., dip 50° to 70° SW. It is traceable on the surface for about 700 feet. Its width ranges from a few inches to as much as 6 feet. Mineralization consists of lead carbonates with occasional spots of galena. These lead minerals carry some silver.

The property has been developed by an inclined shaft, on the vein, 190 feet, with levels at 60, 100, 150, and 190 feet. Only some 15 to 25 feet of drifting has been done on any of these except the 190-foot level where there is a drift north 45 feet, and on the 150-foot level, where there is a drift north 35 feet. Stoping has been done north of the shaft from the 190-foot level to about 25 feet above the 150-foot level for a length of about 30 feet. Five carloads of ore was shipped from these workings between 1927 and 1941. These cars averaged 2.7 ounces of silver, 16 percent lead, and about 2.0 percent zinc. The last car that came from the bottom of the shaft contained 23.0 percent lead, 2.20 ounces silver, and 2.4 percent zinc.

The present lessees have obtained a development loan from the Reconstruction Finance Corporation and expect to immediately (March 1943) begin sinking the shaft and extracting ore from existing levels.

Lavic Mountain Manganese Mine (*Garinger Mine*). It comprises 10 claims situated on the southeast slope of the Cady Mountains, in secs. 22 and 23, T. 8 N., R. 7 E., S. B., 7 miles northwest of Ludlow, 3½ miles north of Argos, a station on the Santa Fe Railroad; elevation 2900 feet. Owners are Lee W. Yim and A. N. Rabe of Ludlow, California. The property is under lease and option to Red Hill Gold Dredging Company, Walter Johnson, president, Charles L. Schifferle, secretary, and J. M. Elmer, manager, 311 California Street, San Francisco.

In 1917, the property was owned by I. D. Garinger, Daggett, California, and L. G. Root, Needles, California. In October 1917, 100 tons of selected ore was shipped to Lewellyn Iron Works, Torrance, California. Analysis showed manganese 35 percent, silica 12 percent, iron 0.5 percent.

Three manganese-ore outcrops occur on the claims on top of ridge in a belt some 200 feet in width and about 1500 feet in length. The main or west outcrop strikes east, dips 75° N., is 2 to 15 feet wide. The ore occurs against a hard red rhyolite agglomerate, along the southwest slope of the ridge. The ore is psilomelane and pyrolusite, with a gangue of silica, calcite, and unaltered fragments of rhyolite. Average sample of ore along outcrops is reported to carry manganese 32.6 percent, iron 1.2 percent, silica 18.0 percent. Total possible tonnage of ore carrying 25 percent grade is estimated to be 10,000 tons.

Development consists of a shaft 48 feet deep sunk along main outcrop; about 1500 feet east of shaft are two open cuts 6 to 8 feet deep and 20 feet in length. Width of ore is 4 to 6 feet; ore is reported to assay 30 percent manganese. Present work is confined to shaft; at depth of 48 feet, drift 20 feet in length in mixed ore. From surface cuts east and west of shaft, there is indicated ore shoot 30 feet in length and 6 feet wide, assaying 20 percent manganese.

Present operators are making screen tests on ore extracted during development work to determine if product containing 35 percent manganese can be produced. Ore screened through $\frac{3}{8}$-inch screen indicates 70 to 80 percent ore, assaying 30 percent manganese. Oversize is discarded as waste. Three men are employed.

Bibl.: Bull. 76, p. 62; State Mineralogist's Reports XVII, pp. 355-356; XXVII, pp. 337-338.

Mine Development Company. This company, Hewitt S. West, president, Pasadena, California, James I. Moore, manager, San Bernardino, California, has had a lease on the Pride of Mojave mill, 4 miles south of Mojave, and on 12 mining claims owned by George A. Barrington, in the so-called South Field of El Mirage Lake district, about 10 miles northwest of Adelanto.

During the tenure of its leases, both of which have now been relinquished (March 1943), the company shipped and treated between 600 and 700 tons of tungsten ore which is reported to have averaged $\frac{1}{2}$ percent WO_3.

Ord Mountain Mine. This mine, comprising 22 claims, 17 of which are patented, is situated in the Ord Mountains, 14 miles southeast of Daggett; elevation 4000 to 5500 feet. Owner is Frank A. Werner, 2029 West Washington Street, Los Angeles. Property is under option to Symons Brothers Screen Company, 100 North Orange Drive, Hollywood, California.

The present lessee has confined his operations to the Rio Vista workings. Former developments here consisted of the lower crosscut tunnel driven east 770 feet, with a drift south 437 feet and north 100 feet, at 700 feet from the portal. The upper tunnel, approximately 125 feet above, was driven as a crosscut east 250 feet, with drifts north and south. A sublevel, intermediate, and upper level were developed through a 175-foot raise from this tunnel. The sublevel is 50 feet above crosscut, intermediate is 40 feet above sublevel, and upper level is 80 feet above the intermediate. The present operator has put up a raise 80 feet above sublevel from which he shipped 4 cars of ore. Four other cars have been shipped from various places in these workings. The company is now cleaning out the upper level and expects to raise to surface from its north end. This is a part of a development program which it is hoped will develop sufficient ore to warrant the erection of a mill.

Equipment at mine consists of 105-cubic-foot compressor, blacksmith shop and 75-ton bin. A camp to accommodate some 25 men has been provided. They are working from 12 to 15 men.

Bibl.: State Mineralogist's Reports X, p. 528; XII, p. 234; XIII, p. 326; XV, p. 789; XVII, pp. 276-278; Bull. 50, p. 336.

Placers, Inc. W. T. Thurman and associates, of Lodi, California, have leases and options from various owners on some 150 acres about one mile north of the Union mine at Atolia.

This property appears to be typical of the placer ground in this area. There is some 12 to 14 feet of overburden, with from 3 to 6 feet or more pay dirt.

The material is loaded into a 6-yard hopper by a $2\frac{1}{2}$-yard dragline shovel; from hopper to $5\frac{1}{2}$- by 20-foot drier trommel (oil fired), trommel openings 1 inch; oversize to tailings stacker; screenings by drag conveyor to hopper to belt conveyor to centrepact mill. This equipment is one unit mounted on one frame, which, in turn, is mounted on caterpillars. From centrepact mill to conveyor to the dry concentrator unit, hopper to 38-inch by 20-foot trommel, ¼-inch openings; oversize by conveyor to tailings stacker; screenings to V-shaped bin under the trommel from which it is fed to a battery of Mexican-type dry washers on each side of the bin; tails to conveyor to stacker. This unit is also mounted on caterpillars. Both units are of all-steel construction. Capacity expected to be 100 yards per hour. The concentrates are then sluiced over 15 feet of riffles to a 30-inch Straub ball mill to a pan amalgamator to a Straub table, to drier and electric separator in a centrally located stationary plant. All machines are motor-driven. Power is supplied by Southern Sierras Power Company.

Nine men are employed. They expected to be in operation by the middle of February 1943.

Spud Patch Placer. Hoefling Brothers, P. O. Box 786, Sacramento, California, have a lease on about 200 acres, comprising the entire Spud Patch, about a mile southeast of Atolia. Allen E. Jones is in charge of operations.

This ground was intensively worked during World War I, when many tons of scheelite were produced by hand work. The material recovered from the sand and gravel of this area was almost pure scheelite in rounded pieces from the size of a walnut or smaller to those weighing almost a hundred pounds. In this area, which is something over a mile long and more than a quarter of a mile wide, there is from 8 to 40 feet of overburden under which is the pay streak averaging about 3½ feet in thickness. There is no real bedrock, the material underneath being similar to the overburden. Boulders weighing 200 pounds or more are very scarce. The pay streak is sand and fine gravel, 80 percent of which will go through a 10-mesh screen, and there is less than 10 percent slime. As in practically all placer deposits, there are, in places, concentrations of values greater than the average. These are believed to occur along the courses of old stream beds.

The ground is stripped and mined by a bulldozer which delivers the material to one 2-yard and one 1½-yard dragline shovel by which it is loaded into trucks and hauled 4 miles northeast to the washing plant on the slope west of Cuddeback Dry Lake. Here it is dumped either into a 30-ton hopper or on a stock pile. From the stock pile, a tractor with blade delivers it to hopper as needed. From the hopper by pan feeder to 6- by 25-foot trommel with a 10-foot scrubbing section, ⅝-inch, with 10-mesh jacket screen; minus 10 pumped to two 2-cell Pan American jigs, the hutch from which goes through Triton continuous amalgamators and then over a Straub table. The minus ⅝-inch plus 10-mesh goes to a 2-cell Bendelari jig, hutch back to 10-mesh circuit; plus ⅝-inch minus 1-inch goes to a 2-cell Bendelari jig. The plus 1-inch from trommel goes to tailings stacker belt over a section of which is built a ''dark room'' in which a large ultraviolet-ray light is mounted over the belt. Two men pick spuds from the belt. This plant is a converted boat which formed part of a dragline dredge.

Water is obtained from 3 wells, half a mile, one mile, and 1½ miles distant. Deep well pumps deliver the water to a reservoir 125 feet in diameter in which about 8 feet of water is stored. The plant has a capacity of 70 yards per hour and is operated at capacity 10 hours each day. Electric power is supplied by Southern Sierras Power Company.

Fifteen men are now working. A full crew would consist of 20 men.

Bibl.: State Mineralogist's Reports XV, pp. 830-839; Bull. 95, pp. 144-145.

Stewart Manganese Mine. This mine comprises 12 claims situated in the Whipple Mountains, in sec. 6, T. 3 N., R. 25 E., S. B., 42 miles by road southeast of Needles, 6 miles southeast of West Well and 14 miles by road to Needles-Blythe road; elevation 1500 feet. There is a 72-mile truck haul to stock pile at Parker, Arizona. Owner of the property is J. W. Stewart, of Needles, Arizona. It is under lease to Mineral Materials Company, A. S. Vinnell, president; Claire W. Dunton, manager; and C. H. Pierce, superintendent, 1182 Masselin Avenue, Los Angeles.

A series of parallel veins occurs in andesite and andesitic breccia; strike northwest. Dips vary from 60° to 70° SW. Widths vary from 12 inches to 3 feet. Four veins have been exposed on the property by open cuts, shallow shafts and short tunnels. The ore mined is psilomelane, associated with pyrolusite. Average grade of ore shipped is 30 percent manganese.

The principal development work is confined to No. 1 vein which occurs along a fault fracture in andesite. The mineralized zone is 25 feet wide and 75 feet in length, with a 3-foot vein of manganese on the footwall. Vein strikes N. 30° W., dips 70° W. There is an open cut on the vein 70 feet in length and 12 feet in width. Twenty feet below the open cut, a tunnel is driven southeast 60 feet. Ore from open cut and tunnel goes to 50-ton ore bin. These workings have produced 150 tons of ore reported to carry 31 percent manganese.

No. 2 vein has been developed by a short tunnel 20 feet in length. On No. 3 vein a shaft has been sunk to a depth of 14 feet, with a drift 20 feet in length on the vein. The vein material is mixed with fragments of andesite. Screen tests of this material produced 30 percent manganese in the fines. No. 4 vein has been exposed on the surface by open cut 200 feet in length. Width of ore exposed is 12 inches to 2 feet.

Equipment consists of 3 portable compressors, one with a capacity of 365 cubic feet, the others have a capacity of 110 cubic feet; tractor and trucks.

At present, they are hauling ore to Metals Reserve Company's stock pile at Parker, Arizona. Ten men are employed.

Vulcan Iron Mine. This mine, comprising 7 claims, is in sec. 25, T. 10 N., R. 13 E., S. B., on the north slope of the Providence Mountains, 9 miles south of Kelso, a station on the Union Pacific Railroad. The property has been purchased from C. Colcock Jones by Kaiser Company, Inc., Henry J. Kaiser, president; offices, Latham Square Building, Oakland, California; local office, Fontana, California; Robert E. Tally, superintendent; George Havas, chief engineer.

This iron deposit is in dolomitic limestone at its contact with quartz monzonite. The deposit strikes east. The contact, forming the western limit, dips 70° W. The monzonite occurs at the west end. The limestone envelopes the other three sides. The deposit is approximately 300 feet wide by 1000 feet long and is estimated to contain 2,500,000 tons of ore averaging about 51 percent iron.

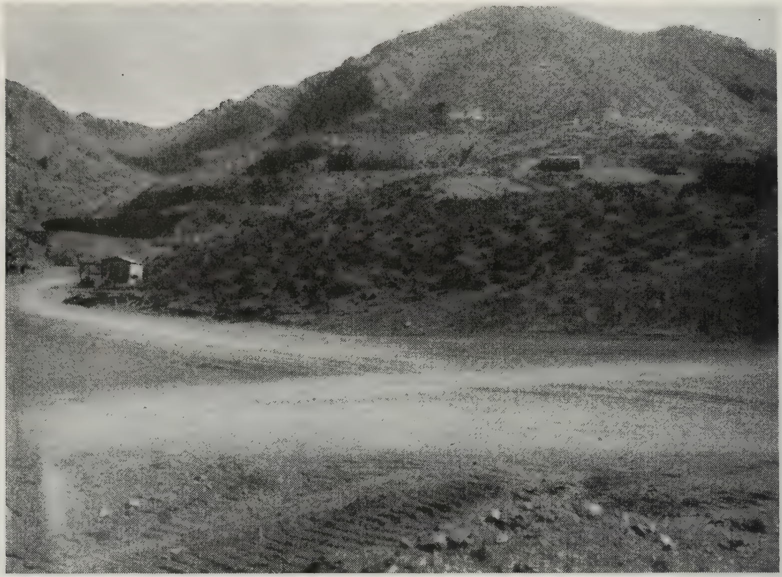

FIG. 2. Vulcan iron mine, Kaiser Company, Inc., showing open cut and two upper benches. Nine miles south of Kelso.

The deposit is being developed by an open cut and two benches. The open cut, which is at the base of the mountain, is some 400 feet long by 300 feet wide by 60 feet deep. The west end of this cut is at the contact. The east end of the cut rises about 60 feet to the floor of the lower bench which is approximately 50 feet wide by 300 feet long. The face of this bench is some 40 feet high. The upper bench, 60 feet above, is 40 feet wide by 150 feet long. The length is now being extended to the north. From this bench, the east end of the deposit will be mined from this level to the top, a vertical distance of 127 feet.

The benches are drilled with $2\frac{1}{2}$-inch Sullivan rotary and 9-inch churn-drill holes to 10 feet below the bottom. The holes are blasted with 60 percent dynamite. The average shot breaks 30,000 tons. Ore is loaded into 22- and 33-ton trucks by two $2\frac{1}{2}$-yard power shovels. It is hauled to a hopper at the level of the lower bench, then fed to 42- by 48-inch jaw crusher, where it is crushed to minus 8 inches; it then falls onto a stock pile. An inclined 40-inch conveyor, in a tunnel under the stock pile is fed by an apron feeder and empties directly into trucks. These trucks haul 9 miles over an oiled road to a stock pile on a siding at Kelso; from stock pile through apron feeder to 40-inch belt equipped with automatic weighing device, direct to railroad cars. They are shipping 2400 tons daily to the Iron & Steel Plant of Kaiser Company, Inc., Fontana, California.

Power is supplied by 280-horsepower Fairbanks-Morse diesel engine, direct-connected to 186-kw generator. A modern camp to house 65 men has been built. One hundred men are employed, 35 families living in trailers at Kelso.

Bibl.: State Mineralogist's Reports XV, pp. 820-821; XXVI, p. 264; Bull. A. I. M. E., Sept. 1915, p. 1889; A. & M. J., April 17, 1909.

Iron & Steel Plant of Kaiser Company, Inc. This plant is located at Fontana, California. Henry J. Kaiser is president, Thomas Price, manager, and George R. Ramsay, assistant manager. Plant capacity is 2500 tons of iron ore per 24 hours. Plant was blown in December 1, 1942. It is located on 1400 acres near Fontana, San Bernardino County. The plant consists of 90 coke ovens and blast furnace about 25 feet in diameter by 100 feet in height. Blast furnace treats iron and limestone at a temperature of 2700°. From blast furnace, pig iron will go to 5 open-hearth furnaces where iron will be mixed with scrap metal, then heated to 3500°, and made into steel. Open-hearth building is 500 by 700 feet. Steel billets from open-hearth furnaces go to rolling mill. The rolling-mill building is 1100 feet in length by 300 feet in width. There is also a by-products plant for coal-tar products and benzoil. The coal for coke ovens is shipped to the plant from Utah. Limestone is furnished by California Cement Company, Colton, California. Six thousand men are employed.

Vulcan Mine (*McClintock*). This gold-copper property comprises 6 claims situated on the northwest slope of Ship Mountains, in Sec. 11, T. 5 N., R. 15 E., S. B., 2½ miles southeast of Siam, a station on the Santa Fe Railroad; elevation 1600 feet. Owner is Helen C. King, 1030 South Magnolia Street, Los Angeles. The mine is under lease to Vulcan Mining Company, Leon O. Compton and H. I. Schuyler, Cadiz, California.

Located in 1898 by McClintock, the property has been worked off and on to date. From 1935 to 1937, it was under lease to Funk Brothers and H. J. Jackson, Ludlow, California. During this period the production was $50,000 in gold, the ore being mined from the 100-foot level to surface. Ore shipped is reported to have averaged $40 per ton in gold. From February 1941 to February 1942, the property was under lease to Rashly, Inc., William W. Dowsing, president, R. C. Aurand, secretary, Santa Monica, California. They shipped 1500 tons of ore to American Smelting & Refining Company's smelter, Hayden, Arizona. Shipments carried the following values: gold 0.345 ounces, silver 0.12 ounces, copper 0.21 percent, silica 70 percent, alumina 10 percent, iron 5.1 percent; total value $11.54 per ton.

The gold vein occurs in quartz diorite; strike N. 10° E., dip 80° E.; width 8 to 12 feet. In the hanging wall of the gold vein and parallel to it, is a copper vein which occurs on the contact of quartz diorite and limestone. Limestone is the hanging wall, quartz diorite the footwall. The copper vein has the same general strike as the gold vein and is from 6 to 12 feet in width. The copper vein carries from 2 to 3 percent copper and $6 in gold.

Development consists of two vertical shafts. South shaft is 175 feet deep, and 150 feet north of this shaft, the north shaft has been sunk to a depth of 500 feet. The present mining and development work is being done from the south shaft. On the 50-foot level, drift 150 feet north to north shaft and 125 feet south; on the 100-foot level, drift 285 feet south, of which 100 feet was on the vein and 125 feet north on 150-foot level, drift north 150 feet to north shaft; on 175-foot level drift north 25 feet. From 100-foot level to surface, the gold vein has been stoped both north and south of shaft. Copper vein is stoped from the 150-foot level to 50-foot level.

Mine equipment consists of 12-horsepower Thomas hoist, (12 by 12 inches); Ingersoll-Rand compressor; air drills; cars; and 3-ton truck. Six men are employed.

White Moon Magnesite Mine. This mine comprises White Moon placer claim, in the NW¼ sec. 22, White Moon No. 2 placer claim in the NE¼ sec. 22, White Moon No. 3 placer claim in the SW¼ sec. 15, White Moon No. 4 placer claim in the SE¼ sec. 15, T. 8 N., R. 21 E., S. B., total 640 acres, in the Sacramento Mountains, in Sunrise mining district, 11 miles southwest of Needles; elevation 2000 feet. Owners are B. E. Hubbard and William W. White and associates, 6263 Vesper Street, Van Nuys, California; under option to J. Lex Brown, 1850 Waterman Avenue, San Bernardino, California. The property is subleased to American Magnesite Company of America, Irving Bromberg, president; A. Bromberg, secretary; M. I. Lieberson, manager; H. A. Pelton, engineer, 1349 Washington Boulevard, Los Angeles; J. Lex Brown, superintendent.

A stratum of magnesite occurs along anticlinal fold in dolomite, and overlies a thick series of volcanic rocks, andesite and andesitic breccia. The general strike is northwest, dips vary. The general dip of the stratum is 15° NE. The sedimentary bed of magnesite is intensely folded and tilted. Sufficient development work has not been done on the bed to determine its thickness, which is probably 8 to 10 feet. The dolomite beds overlie the bed of magnesite, having a thickness of 8 to 10 feet. The exposure of magnesite can be traced on the surface for a distance of 750 to 1000 feet.

Development consists of a number of shallow trenches, short tunnels and open cuts made at intervals along the bed of magnesite. Estimated tonnage of probable ore developed is stated to be 40,000 tons of commercial grade.

They are building a road from Needles to the deposit 11½ miles in length. The company has acquired the Chula Vista calcining plant formerly operated by the Tycrete Chemical Corporation, Chula Vista, San Diego County. The plant has a capacity of 100 tons per day. They plan to ship the magnesite from deposit to Chula Vista for treatment. Six men are employed on construction of road and development work on an open cut on the southeast end of deposit.

SACRAMENTO FIELD DISTRICT

CURRENT NOTES ON ACTIVITY IN THE STRATEGIC MINERALS, SACRAMENTO FIELD DISTRICT

By CHARLES V. AVERILL*

OUTLINE OF REPORT

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AMADOR COUNTY

Copper

Newton Mine. This mine is four miles east of Ione on the highway to Jackson. It was opened in the early sixties and was equipped with an 80-ton smelter in 1889. Until the mine was reopened recently, the last production had been in 1900. Workings reached a depth of 430 feet. The mine is now being operated by J. H. Lester, who obtained a preliminary development loan from Reconstruction Finance Corporation. The first carload of ore was shipped in April 1943. Diamond drilling by the U. S. Bureau of Mines is said to have proved that ore exists at greater depth than mine workings have reached.

CALAVERAS COUNTY

Quartz Crystals

Rough Diamond Mining Co. This company is reopening the Green Mountain or McSorley quartz-crystal mine in secs. 18, 19, T. 5 N., R. 12 E. and sec. 24, T. 5 N., R. 11 E., M. D., two miles south of Mokelumne Hill, with funds derived from a preliminary development loan granted by Reconstruction Finance Corporation. Crystals are found in a buried river channel, and between 1897 and the close of the war of 1914-18 shipments of 22 tons were made. Such material is in great demand for war purposes, as wafers of the quartz about an inch square are used to control the frequency of all radio transmitters including those installed in airplanes and military tanks. Such quartz must contain no flaws.

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* District Mining Engineer, Sacramento Field District, Division of Mines. Manuscript submitted for publication May 6, 1943.

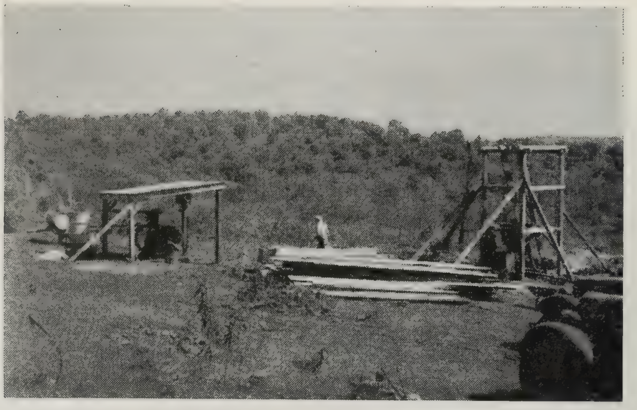

FIG. 1. Chaix chrome mine operated by C. D. Jones.

EL DORADO COUNTY

Chromite

Chaix Mine. During the war of 1914-18, this mine produced at least five carloads of chrome ore. It is in sec. 14, T. 8 N., R. 9 E., M. D., two miles east of Latrobe. The mine is now (May 1943) being reopened by C. D. Jones of Rescue with funds derived from a preliminary development loan granted by Reconstruction Finance Corporation. Shipments of chrome ore are expected to start soon.

Joerger Mine. This property in sec. 35, T. 10 N., R. 8 E., M. D., is two miles by dirt road from a point on the Sacramento-Placerville highway near Clarksville. It probably produced several carloads of chrome ore during the war of 1914-18. Chas. C. Holden of Rescue is leasing it from J. E. Joerger, Clarksville. Holden is now (May 1943) starting to reopen it with funds derived from a preliminary development loan granted by Reconstruction Finance Corporation.

Copper

Dodson Mine. This property has been known also as the Rip and Tear copper mine. It is in sec. 3, T. 8 N., R. 9 E., M. D., two miles north of Latrobe. It is leased by W. J. Varozza of Latrobe, via Shingle, from R. L. Dodson of the same address. A little copper ore of good grade was shipped in 1917, and the mine is believed to contain more such ore. Varozza expects to reopen it soon with funds derived from a preliminary development loan granted by Reconstruction Finance Corporation.

Volo Mining Company. This company recently operated a mill for the production of chrome concentrates in sec. 22, T. 10 N., R. 10 E., M. D., three miles southeast of Placerville. The mill has been remodeled to make copper concentrate by flotation. F. V. Phillips, Box 586, Placerville, is in charge. He is reopening the Lillyama mine in sec. 3, T. 11 N., R. 9 E., M. D., 15 miles northwest of Placerville.

NEVADA COUNTY

Chromite

Parker Chrome Mine. This mine is in sec. 17, T. 13 N., R. 8 E., M. D., half a mile east of the Auburn-Grass Valley highway at a point 6½ miles north of Auburn. It is leased from Herman Oest by Chester C. Butler, Grass Valley, and John C. Wold, Auburn, who are reopening the mine with funds derived from a loan granted by Reconstruction Finance Corporation. Chrome ore was produced during the war of 1914-18.

Manganese

Stearns and Owens. This is the name of new operators, whose address is Box 661, Auburn, of the manganese mine formerly operated by Mangachrome Company, a partnership of Neville and Slater. The mine is in sec. 17, T. 14 N., R. 8 E., M. D., at the junction of the Lime Kiln and Wolf roads. The former operators delivered roughly 500 tons of manganese ore to Metals Reserve stockpile at Auburn. Mining is by open-pit methods.

The pit is now 450 feet long, 50 feet wide, and 25 feet deep in four benches. A cross-section at the south end shows that it is mostly in slate striking N. 15° W., and dipping 76° E. Some interbedded volcanic material, probably basalt of very fine grain, is seen in beds from a few feet wide to 10 feet wide; there are also a few beds of chert 2 feet wide. Black oxides of manganese occur in occasional lenses, which contain some rhodonite. This is discarded in hand-sorting.

Present operators are continuing operations in the pit with a diesel 75 Caterpillar tractor and 12-cu. yd. Bucyrus Erie carryall. They also have an 8-cu. yd. carryall not in use, portable air compressor, and other power-tools and trucks.

REDDING FIELD DISTRICT

CLERBUS-MAE TUNGSTEN PROSPECT, TRINITY COUNTY

By J. C. O'Brien*

The Clerbus-Mae tungsten prospect consists of two unpatented quartz claims located in sec. 31, T. 9 N., R. 8 E., H., in the New River mining district of Trinity County, about 30 miles north of Denny by mountain trail, and about half a mile west of Eagle Creek, at an elevation of 4000 feet. Owners are Burtt L. Berry, 1451 Larkin Street, San Francisco, and Jim Robie, Fairfax, California.

This property was formerly operated as a gold mine by Andrew Jacobsen and partners, who treated the ore in a small elliptic mill, impact amalgamator, and a small Wilfley-type concentrating table run by a 4-horsepower single-cylinder gas engine. The quartz is said to have averaged $13.00 a ton, but recovery was poor.

The mine is developed by an adit driven S. 10° W. through diorite. The diorite shows jointing that strikes S. 50° E., and dips 77° NE. About 80 feet from the portal, a 2-inch quartz vein dipping 60° N. was followed S. 80° E. for about 40 feet. Both walls of the vein are diorite. Scheelite fluorescence was prominent in the vein about 30 feet from the adit, where small vugs and iron stains seem to be more prominent. The fluorescence is strongest at the hanging-wall contact with the diorite, which has been altered for a depth of a quarter of an inch. The feldspar and many of the dark minerals seem to have been removed and replaced in part by quartz. It may be that the tungstic acid solution acquired its calcium to form scheelite from the feldspar in the diorite. No calcite was observed in the vicinity of the vein and no cross-fractures or seams were observed where the fluorescence was strongest. The vein quartz has a slight ribbon structure, indicating successive periods of deposition.

A parallel quartz vein about half an inch wide occurs in the footwall, and a few fluorescent grains were seen in spots near its east and west faces. The vein was followed about 40 feet west of the adit, but no fluorescence was noted.

These veins outcrop on the hill above the adit, where they are from 4 to 6 inches wide. No scheelite was seen on the outcrop. The scheelite-bearing vein is too narrow and apparently too low-grade for commercial development.

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* District Mining Engineer, Division of Mines. Manuscript submitted for publication April 20, 1943.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins*

In This Issue

Four contributions on geology and mineral deposits are published in this issue: (1) a description of a new rock, by Raymond M. Alf, *Mylonites in the Eastern San Gabriel Mountains;* (2) a geologic map of metamorphic and granitic rocks in an area in the southern Sierra Nevada, with a description of them, by Cordell Durrell, *Geology of the Sierra Nevada Northeast of Visalia, Tulare County, California;* (3) a description of tungsten deposits found in this area, by William O. Jenkins, *Tungsten Deposits Northeast of Visalia, California;* and (4) a geologic map prepared in great detail of an area in the Coast Ranges, by Ivan F. Wilson, *Geology of the San Benito Quadrangle, California.* This geologic map is published in colors and covers a topographic quadrangle of the U. S. Geological Survey. It represents the first of a series of such maps which the Division of Mines expects to issue.

Recent Publication

BULLETIN 118, *Geologic Formations and Economic Development of the Oil and Gas Fields of California,* compiled under the direction of Olaf P. Jenkins, is now released under one cover. It consists of four parts, as follows:

Part One—Development of the Industry, pp. 1-80.
Part Two—Geology of California and the Occurrence of Oil and Gas, pp. 81-276.
Part Three—Descriptions of Individual Oil and Gas Fields, pp. 277-664; including tabulated data on wells drilled outside of the principal oil and gas fields; also citations to selected references, throughout Part Three.
Part Four—Glossaries, Bibliography, and Index, pp. 665-773; includes glossary of the geologic units of California, bibliography, and index to the entire volume.

Bulletin 118 contains 6 plates, 283 figures, 81 index maps to individual oil and gas fields (on the same scale as the Geologic Map of California—1:500,000), and an Outline Geologic Map of California Showing Oil and Gas Fields and Drilled Areas—Economic Mineral Map of California No. 2, Oil and Gas, scale 1:1,000,000 (folded in pocket).

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* Chief Geologist, Geologic Branch, Division of Mines.

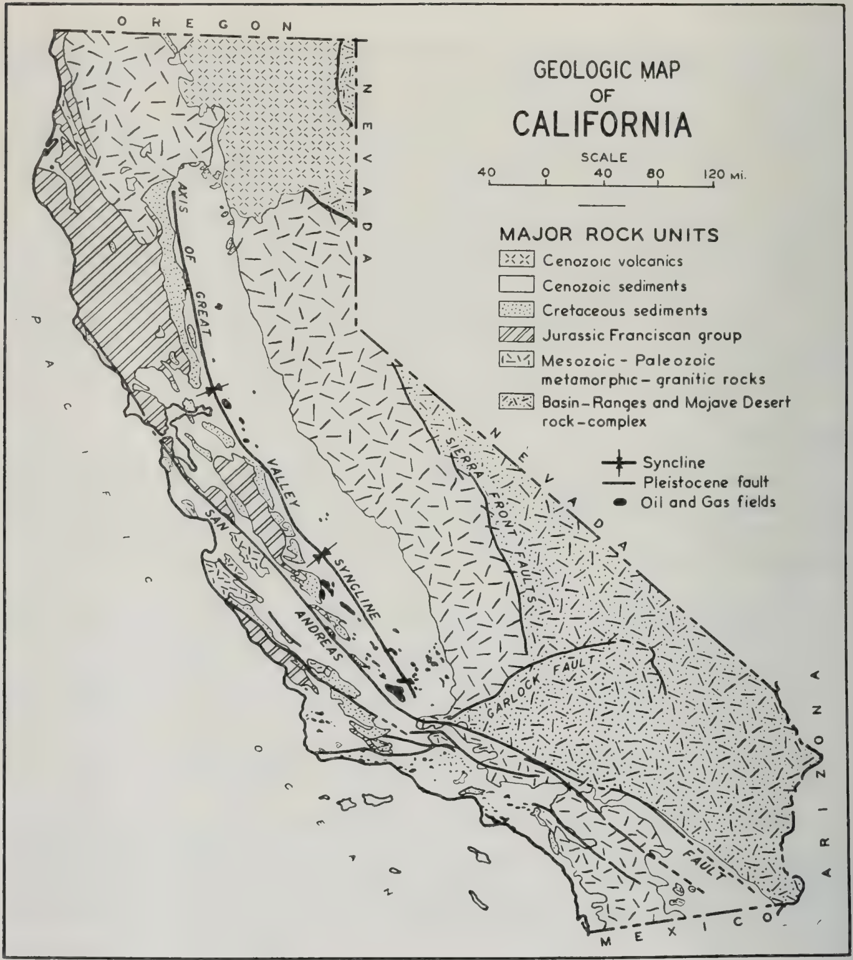
GEOLOGIC MAP
OF
CALIFORNIA
SCALE
40 0 40 80 120 Mi.
MAJOR ROCK UNITS
Cenozoic volcanics
Cenozoic sediments
Cretaceous sediments
Jurassic Franciscan group
Mesozoic - Paleozoic metamorphic - granitic rocks
Basin - Ranges and Mojave Desert rock - complex
Syncline
Pleistocene fault
Oil and Gas fields
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
AXIS OF GREAT VALLEY SYNCLINE
SAN ANDREAS FAULT
SIERRA FRONT FAULTS
GARLOCK FAULT

FIG. 1. Generalized geologic map of California showing major rock units, major structural lines, and oil and gas fields. *Prepared by Olaf P. Jenkins.*

MYLONITES IN THE EASTERN SAN GABRIEL MOUNTAINS

By Raymond M. Alf *

OUTLINE OF REPORT

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ABSTRACT

The author has discovered thick zones of the dense crush-rock, mylonite, in the Cucamonga district 40 miles east of Los Angeles, an area already well known to geologists because of large and complicated alluvial fans and notable Pleistocene and Recent faulting.

Mylonites are fine-grained rocks which may look like smeared porphyries or even banded chert. They are composed of fragments most of which are very small, but unlike gouge they are firm and solid rocks, probably because they were formed at depths and under pressures where cavities could not persist.

The mylonite zones of the Cucamonga district are roughly paralleled by the Pleistocene faults. Both occur along the mountain front and curve up canyons. However, the mylonites formed much earlier than the Pleistocene, probably during the late Mesozoic, for they seem to grade into schists and gneisses, they are intruded by granitic rocks, and they furnished abundant debris to nearby Tertiary sediments. Most notable is the preservation here, perhaps as well as anywhere in North America, of what appear to be the actual stages in the formation of dynamically metamorphosed rocks.

INTRODUCTION

During the summer of 1942, when the writer was engaged in the petrographic study of the southeastern San Gabriel Mountains, he discovered large masses of mylonites in the vicinity of San Antonio Canyon. The study of these rocks is being continued, and the writer hopes to make a more complete report on them at a later time.

The terminology of Waters and Campbell [1] has been found satisfactory and is used here. These authors give a genetic definition for mylonite that has four qualifications:

> "First, a mylonite is a microbreccia produced by the milling down of the original rock material into an aphanitic paste which can only be resolved by the microscope; second, the rock must possess a flow structure, or lamination, as a result of the streaking out of the pulverized paste; third, the pulverization must have occurred under such conditions that the rock retains its coherence; and fourth, the rock must be characterized by cataclastic rather than crystalloblastic textures."

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* Webb School of California, Claremont, California. Manuscript submitted for publication February 11, 1943.

Gratitude is here expressed to Dr. A. O. Woodford for the use of the Pomona College geology laboratories and library and particularly for his help and encouragement in the preparation of this report. Also the writer wishes to acknowledge the cooperation of the Forest Service of the United States Department of Agriculture.

[1] Waters, A. C., and Campbell, C. D., Mylonites from the San Andreas fault zone: Am. Jour. Sci., vol. 29, pp. 474-475, 1935.

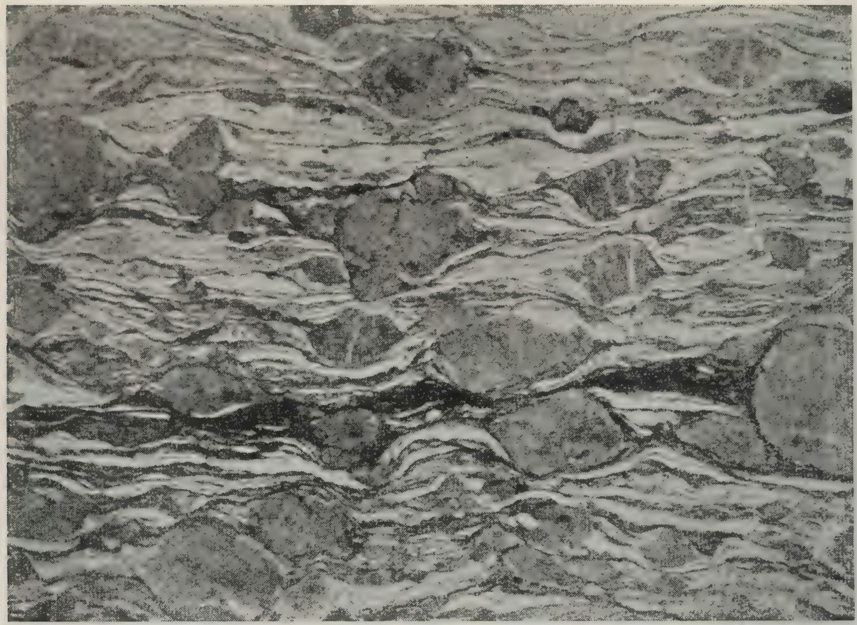

Fig. 1. Photomicrograph of mylonite derived from a granitic rock (ordinary light, x16). The gray areas are orthoclase, and the light areas are mostly quartz. Evey Canyon.

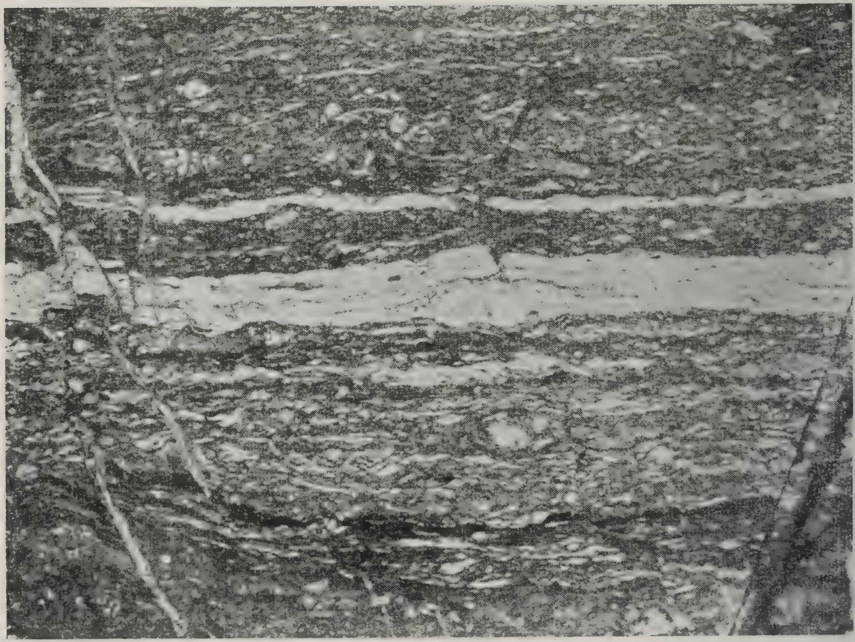

Fig. 2. Photomicrograph of mylonite from Evey Canyon (ordinary light, x16). This was originally a granitic rock.

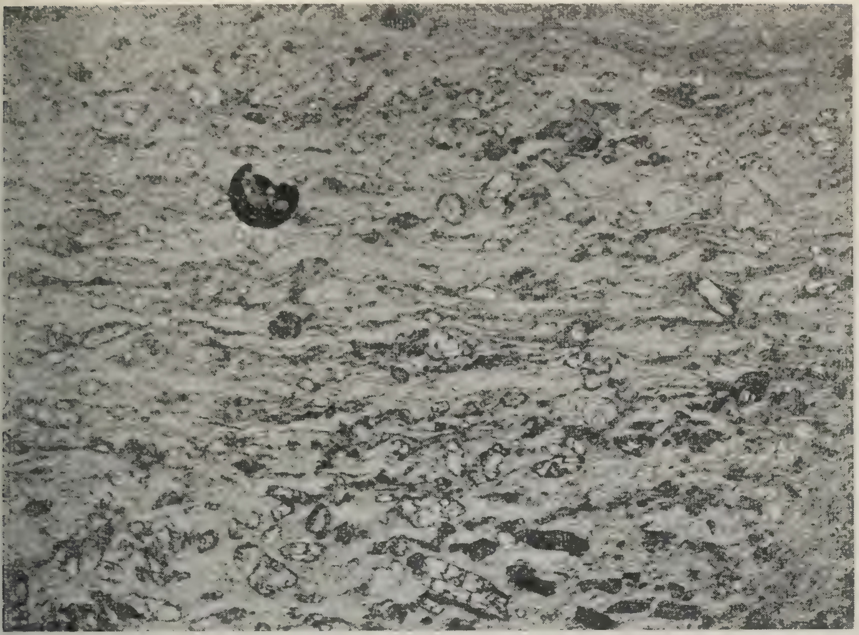

FIG. 3. Photomicrograph of limestone mylonite from Evey Canyon (ordinary light, x16). The large grains are mostly diopside and are probably porphyroclasts.

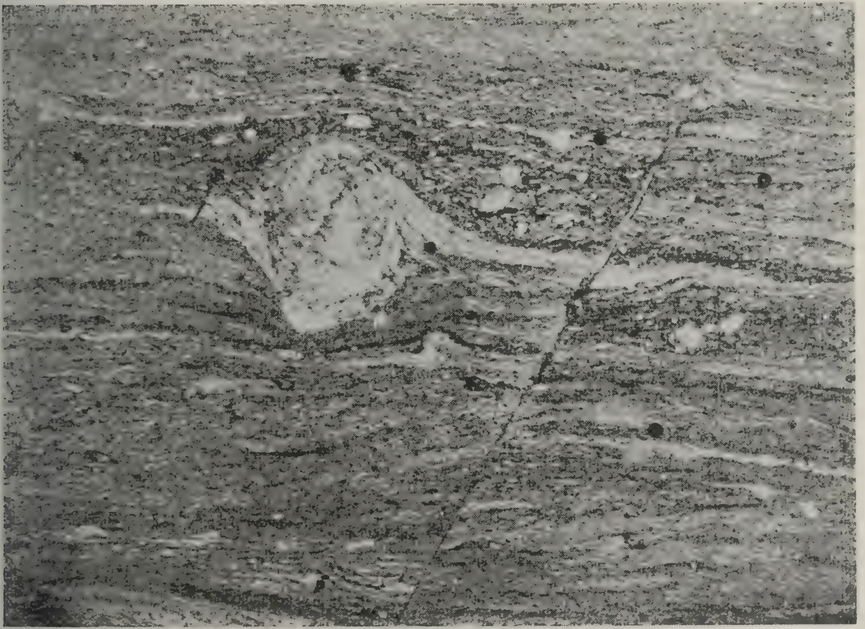

FIG. 4. Photomicrograph of mylonite derived from a dark-gray granitic rock (ordinary light, x16). The porphyroclast is feldspar; it has an irregular nucleus of clear orthoclase (or microcline) and a periphery of albite. Cucamonga Canyon.

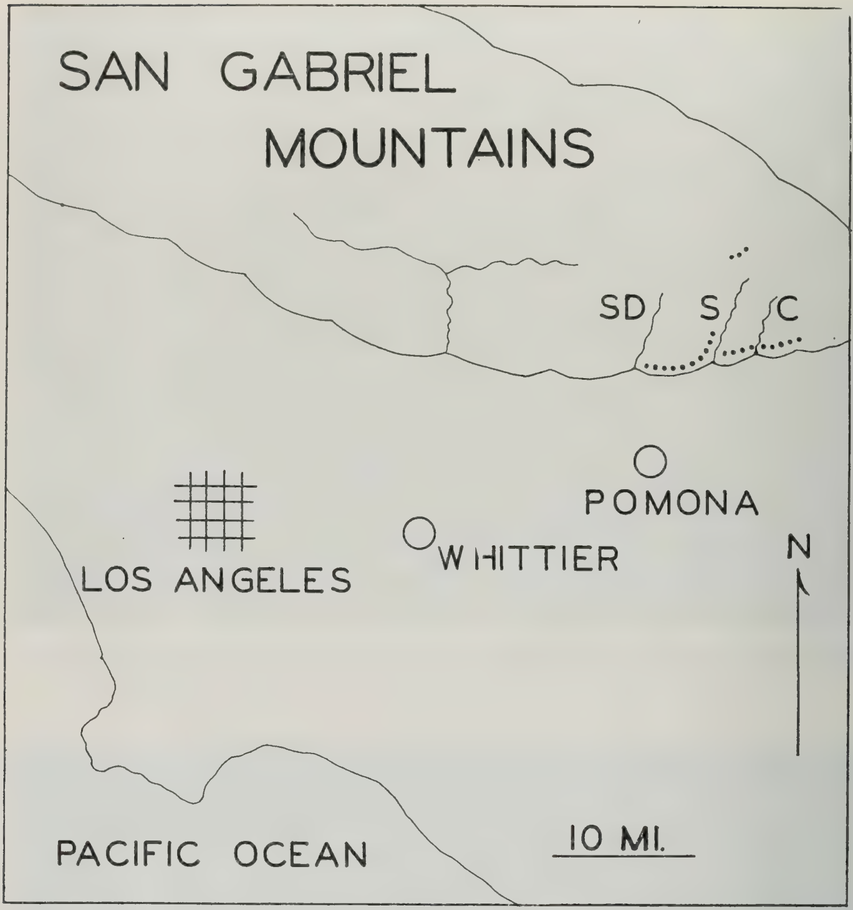

FIG. 5. Map showing locations of mylonite zones (. . . . .). S—San Antonio Canyon; SD—San Dimas Canyon; C—Cucamonga Canyon.

TYPES

The principal mylonite masses in the eastern San Gabriel Mountains are derivatives of granitic rocks (figs. 1, 2). Their general appearance is that of a foliated porphyry whose groundmass is greenish and aphanitic and whose phenocrysts are pink feldspar. This type grades into a dark-green, flint-like rock which has no phenocrysts or flow structure visible to the naked eye, but which is resolved by the microscope into a mylonite. The flint-like rock approaches the type called ultramylonite (Waters and Campbell, op. cit., p. 481). The pink feldspar is orthoclase with a 2V of approximately 50 degrees. Some of the grains are fractured and cut by quartz veinlets, and most of them are clouded with alteration products. Quartz is present as mottled groups of fine grains, each grain showing strain shadows and the group as a whole showing marked fluxion. The most important minor constituent is pale-green and faintly pleochroic chlorite that has an index of refraction of 1.625, and no noticeable birefringence. Translucent particles of hematite are common, and titanite and calcite were observed.

An associated quartzite mylonite, somewhat glassy in appearance, has a faintly greenish luster and perceptible flow structure. Pink feldspars are sparsely distributed throughout the rock. Under the microscope the flow structure is accentuated by fine streaks of altered material. The feldspars are cataclastic and cloudy; quartz is minutely granular and shows pronounced strain shadows.

There are several types of mylonitized limestones. One is made up of alternating light and dark bands, both of which are cut by minute veinlets of calcite. The microscope resolves the bands into a thinly laminated mylonite or ultramylonite, the dark color of which is probably caused by graphite. Another limestone type (fig. 3) is light colored and shows lamination only on weathered surfaces. Microlenticular aggregates of quartz, plagioclase, and diopside are characteristic and show more or less clearly the effect of the milling process. The diopside is pale, clear green, resembling malacolite, the rare pure form reported from nearby Cascade Canyon and from the Crestmore quarries, California.[2] An additional characteristic mineral is a golden-brown biotite or phlogopite that shows slight pleochroism and an extremely small but noticeable 2V.

Particular attention is here called to a dark-gray mylonite containing porphyroclasts of albite that have irregular nuclei of orthoclase or possibly microcline (fig. 4). This relationship suggests that the albite is of metasomatic origin. If metasomatism was taking place at the same time as the mylonitization, some of the finer-grained portions of the rocks, where the texture is obscure, may be at least partially crystalloblastic rather than cataclastic.

DISTRIBUTION

The mylonites occur in several zones, shown roughly in fig. 5. One belt is high on the bold front of the mountains between San Dimas and San Antonio canyons. From Evey Canyon, a western tributary of San Antonio, the tectonic horizon curves northeastward into the main San Antonio Canyon, as shown in fig. 5. The general dip of the underlying contact, probably a thrust plane, is about 40 or 45 degrees to the northwest, and the zone of mylonitization is more than 100 feet thick (fig. 6). A second zone occurs near the base of San Antonio Peak, at the head of San Antonio Canyon, but here the attitude and thickness have not yet been determined.

By far the broadest mylonite zone follows the base of the mountains from San Antonio Canyon eastward for many miles. Cucamonga Canyon cuts across this zone, giving excellent exposures and showing a thickness of several thousand feet of northward-dipping, intimately associated mylonites, schists, and gneisses. Mylonites make up a large part of the section, and appear to grade into schists. Mylonites and crystalline rocks both are intruded by dikes of pegmatite and other plutonic rocks.

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[2] Merriam, R., and Laudermilk, J. D., Two diopsides from southern California: Am. Mineralogist, vol. 21, pp. 715-718, 1936.

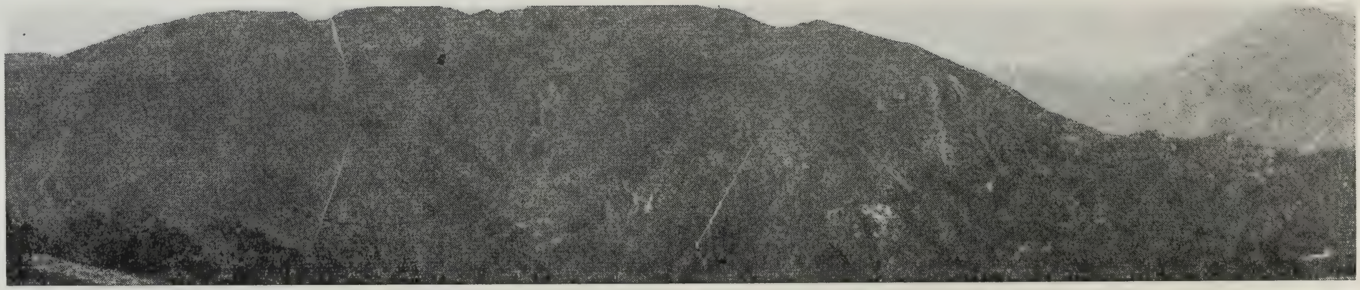

FIG. 6. Panoramic view of mylonite zone in Evey Canyon, showing about 2 miles of mountain front from the SSE. A mylonite band outcrops on the steep, bare slope midway up the mountain front.

The writer knows of no mylonite zones in western North America which are comparable in size to those of the San Gabriel Mountains. In the Appalachian region there are the pre-Cambrian mylonites near Philadelphia,[3] composed largely of cataclastic biotite, which have a maximum thickness of a quarter of a mile.

AGE

Structures in southern California are notably hard to date. However, because the mylonites of the eastern San Gabriel Mountains are cut by plutonic rocks which must be pre-Chico in age,[4] there is some basis for their age determination. Certainly the mylonites are older than the Tertiary and are at least as old as the Mesozoic batholithic intrusion. Whether or not this plutonism took place during the Cretaceous or the Jurassic or even earlier is still not determined (Woodford, op. cit., p. 257).

Speculation concerning the age of the San Gabriel Mountains has been voiced by a number of geologists. W. J. Miller[5] and G. J. Bellemin[6] consider them to be the chief source of the Tertiary clastic sediments, or at least of several of the conglomerates, in the Los Angeles Basin, a belief that implies the existence of the mountains throughout all or a large part of Tertiary time.

Since the discovery of mylonites in the bedrock, a re-examination of some of the Tertiary conglomerates from the Los Angeles Basin has shown that mylonites make up a small part of the Whittier Pliocene sediments and a considerable part of Pleistocene conglomerates on Garfield Avenue, 5 miles northwest of Whittier, and of Miocene conglomerates near Pomona (fig. 5). The coarse Miocene cobble beds are well exposed on the north side of the Pomona-Covina highway, opposite the Kellogg ranch house; they belong to the lower Puente formation (Lower Mohnian stage). Miocene cobbles, in particular, are identical to mylonites (or recrystallized mylonites) from the eastern San Gabriel Mountains and therefore tend to confirm the conclusions of Miller and Bellemin.

A remarkable characteristic of the mylonite constituents of the conglomerates is their resistance to the forces of disintegration, a property that makes possible their transportation to localities many miles from their place of origin.

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[3] Armstrong, Elizabeth, Mylonization of hybrid rocks near Philadelphia, Pennsylvania: Geol. Soc. Am. Bull., vol. 52, pp. 667-694, 1941.

[4] Woodford, A. O., Pre-Tertiary diastrophism and plutonism in southern California and Baja California: Proc. Sixth Pacific Sci. Cong., vol. 1, p. 256, 1939.

[5] Miller, W. J., Geology of the western San Gabriel Mountains of California: California Univ. at Los Angeles, Pub. Math. and Physical Sci., vol. 1, no. 1, 1934.

[6] Bellemin, G. J., Petrology of Whittier conglomerates, southern California: Am. Assoc. Petrol. Geologists Bull., vol. 24, pp. 666-669, 1940.

GEOLOGY OF THE SIERRA NEVADA NORTHEAST OF VISALIA, TULARE COUNTY, CALIFORNIA

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INTRODUCTION

Location of the Area

The area described in this report is a part of the western slope of the southern Sierra Nevada in Tulare County, California. It embraces the lower drainage basin of the Kaweah River and its tributaries, extending about 12 miles eastward from the alluvium of the San Joaquin Valley nearly to the western boundary of Sequoia National Park.

Topography and Physiography

The relief of the region is rugged, ranging from an elevation of about 500 feet near the margin of the San Joaquin Valley, to over 5000 feet on the west end of Ash Peaks Ridge only 12 miles distant. Many of the initial mountain slopes rise more than a thousand feet above the adjacent alluvium of the valley floor. The walls of the principal canyons rise in places more than 2000 feet above the level of the streams.

The drainage pattern is dendritic and, except in the northwestern part of the area, is entirely tributary to the Kaweah River and its several principal branches. The landscape is in a condition of early maturity, and it consists of an intricate pattern of minor streams separated by steep and sharp-crested ridges.

The only stream terraces in the region are along the lower courses of Dry Creek, the Kaweah River, and the South Fork of the Kaweah

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River. Those developed along the two first-mentioned streams are all close to the present stream level, and are the normal result of lateral erosion in combination with down-cutting. The alluviation of the South Fork of the Kaweah, upstream from the narrows a mile southeast of Three Rivers, was due to the local base level constituted by very resistant hornfelses exposed in the narrows. Recent downcutting of that barrier has left the alluviated area as a terrace.

Several highland areas of low relief may conceivably represent remnants of an earlier erosion cycle, but proof that they do so is wanting. Such areas include Quail, Adams, and Shadley Flats in the northwestern part of the map area, Manikin Flat near the center of the map, and Little Oak Flat near the center of the southern margin of the map.

Several large topographic recesses, without prominent interior drainage lines, occur along two of the main streams. These are Washburn Cove and Shepherd Cove, north of Three Rivers, and a similar unnamed feature 2 miles east of Three Rivers on the north side of the South Fork. These peculiar depressions seem to owe their origin to the lesser resistance to weathering and erosion of the rocks which floor them.

Most of the map area consists of grass lands with a light forest of oak, but the northeastern part is brushy in many places. The soil cover is heavy over most of the area but exposures are satisfactory except for the most detailed kind of geologic mapping. Roads are plentiful in the western part, but to the east and northeast the great ridges between the major streams are accessible only on foot or by horse.

Previous Work

When the author first started to work in this region in 1932, no geologic maps of this area nor of adjacent areas were in existence. Henry W. Turner[1] had devoted a little more than one page to observations made while passing through the region. A physiographic study of the southern Sierra Nevada by Hake[2] includes this area. Mapped areas nearest to this include the Mineral King district 20 miles to the east, mapped by Knopf and Thelen,[3] the Kernville quadrangle, 35 miles to the southeast, mapped by Webb,[4] and the foothill region between the Kings and San Joaquin rivers, 20 miles to the northwest, mapped by Macdonald.[5]

The work by the present author was done during the years 1932 to 1936, and was published in 1940.[6] This earlier paper describes in detail the petrology and petrography of the area with particular emphasis on the metamorphism. The reader is referred to that work for a more comprehensive treatment of those fields than is included here.

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[1] Turner, H. W., Further contributions to the geology of the Sierra Nevada: U. S. Geol. Survey, 17th Ann. Rept., pt. 1, pp. 714-715, 1895-96.

[2] Hake, Benjamin, Scarps of the southwestern Sierra Nevada: Geol. Soc. America Bull., vol. 39, pp. 1017-1030, 1928.

[3] Knopf, A., and Thelen, P., Sketch of the geology of the Mineral King district: California Univ., Dept. Geol. Sci., Bull., vol. 4, pp. 227-262, 1905.

[4] Webb, R. W., Descriptive geology of the Kernville quadrangle: California Div. Mines Rept. 36, pp. 343-378, 1940.

[5] Macdonald, G. A., Geology of the western Sierra Nevada between the Kings and San Joaquin rivers, Calif.: California Univ., Dept. Geol. Sci., Bull., vol. 26, pp. 215-286, 1941.

[6] Durrell, C., Metamorphism in the southern Sierra Nevada northeast of Visalia, Calif.: California Univ., Dept. Geol. Sci., Bull., vol. 25, pp. 1-118, 1940.

This present work includes no new results, and is undertaken only to make the general geological features and history more readily available. The motive for this republication is the recent discovery in the region of the ores of tungsten. Small amounts of manganese are also known to occur. It is hoped that the present writing may be of more value to the prospector and mine operator than the earlier one.

The accompanying map includes parts of the Dinuba, Tehipite, and Kaweah quadrangles, and the whole of the Lemon Cove quadrangle, an area of about 350 square miles. The geology of the Rocky Hill quadrangle, which is included in the earlier work[7] has been omitted because it is of less economic interest.

DESCRIPTIVE GEOLOGY

All of the rocks of the area herein described, excepting only the alluvium, belong to the "bedrock complex" of the Sierra Nevada, and are of pre-Cretaceous age. They were involved in, or resulted from, the Nevadan revolution which occurred in the Upper Jurassic.[8]

The rocks of the region may be divided into two groups: (a) the sedimentary and igneous rocks which were folded and metamorphosed during the Nevadan revolution; and (b) the plutonic igneous rocks which were intruded immediately after the folding.

The first group is a thick series of sedimentary, pyroclastic, and volcanic rocks called the Kaweah series,[9] and many igneous intrusive bodies of approximately the same age. All of these sediments and igneous rocks were folded and metamorphosed at the time of the Nevadan orogeny. The Kaweah series is further divided into four stratigraphic units.

The second group of rocks consists of plutonic intrusives which range in composition from hornblende gabbro to granite. The hornblende gabbros are shown separately on the map. All others are shown as a single unit though many separate intrusions are present.

Since the Nevadan revolution the southern Sierra Nevada has been predominantly subject to erosion, and during this long interval of geologic time a great but unknown thickness of metamorphic rocks has been stripped away. Only the lowest portions of the metamorphic rocks now remain. These appear on the map as elongated but irregular bodies surrounded by and embedded in plutonic igneous rocks. Such bodies are known as roof pendants. All available evidence indicates that the bodies were attached to a once-continuous roof of metamorphic rock. They are bodies in place.

Kaweah Series

The Kaweah series consisted originally of a great complex of sedimentary, pyroclastic, and volcanic rocks. These have suffered metamorphism varying from place to place in kind and intensity. Further complexities arise out of the fact that rocks, originally different in origin but similar in composition, become similar in all respects when metamorphosed under the same conditions. The rocks resulting from the metamorphism are highly diversified.

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[7] Durrell, C., *op. cit.*

[8] Taliaferro, N. L., Geologic history and correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America. Bull., vol. 53, pp. 71-112, 1942.

[9] Durrell, C., *op. cit.*, p. 13.

The same rock types occur throughout the whole extent and thickness of the Kaweah series, but not everywhere in the same relative proportion. The fourfold division of the series is based upon the predominance of certain types of rocks in each of the four parts. These four divisions have only arbitrary boundaries, and it appears that two are in part the equivalent of the remaining two. The total thickness of the Kaweah series is approximately 15,000 feet. The sum of the four units is greater than this because of the equivalences mentioned above.

Yokohl Amphibolite

The Yokohl amphibolite, which is the oldest member of the Kaweah series, is best developed in the Rocky Hill quadrangle, south of the area described in this report. On the present map it occurs only on Woodlake Mountain and on a small hill immediately to the north.

The section on Woodlake Mountain consists of nearly 8000 feet of plagioclase amphibolite derived principally from basalt lava flows, tuffs, and breccias. Local thin bands of talc, chlorite, and hornblende schists are present. Amygdaloidal structures, breccia structures, and porphyritic textures are clearly evident. The higher part of the section, east of the summit of the mountain, contains a few thin layers of muscovite schist derived from rhyolite tuffs.

Four thin sills of serpentine, including some talc and chlorite schist, and meta-gabbro occur near the summit of the mountain. These were not mapped because of poor exposure. Intrusions of serpentine and gabbro do not occur any higher in the Kaweah series. Extensive bodies of them occur in the Yokohl amphibolite in the Rocky Hill quadrangle and these have been described in the earlier report on this area.[10] Pillow structures in flows, bedded tuffs and quartzites derived from radiolarian cherts, interbedded with the Yokohl amphibolite in the Rocky Hill quadrangle, show the submarine origin of the stratified rocks.

Lemon Cove Schist

The Lemon Cove schist, which is in part equivalent to, and in part younger than the Yokohl amphibolite, occurs in three belts. The largest area is that along Dry Creek where the schist is folded into the Dry Creek anticline. It is also exposed along Sheep Creek, which is tributary to the North Fork of the Kaweah, in the core of the Sheep Creek anticline. A narrow belt follows the eastern margin of the Kaweah series between Yucca Creek and Eshom Valley, and dips west under the Sheep Ridge syncline.

Quartz-muscovite-biotite schist and phyllite are the most abundant rock types. These were derived principally from the metamorphism of silicic tuffs with various degrees of admixture of fine sediment. Along the lower course of Dry Creek and westward toward Woodlake Mountain the original character of these rocks may be clearly seen. Flattened lapilli, probably originally pumiceous, are set in a darker more richly micaceous matrix. Phenocrystic crystals and fragments are abundant. Occasionally undistorted originally igneous rock fragments may be found. Where more highly metamorphosed, the originally tuffaceous rocks are finely banded and gneiss-like.

Fine mica-rich, often graphitic phyllites derived from argillaceous sediments occur east of the lower course of Dry Creek. Immediately east of the axis of the Dry Creek anticline, and extending northwest for about 3 miles from its southern termination at the Kaweah River, is a quartz-mica schist derived from fine sandstone and siltstone. This massive but obviously bedded unit has a maximum thickness of about 400 feet. To the north it becomes finer grained and grades into phyllites through decrease in grain size.

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[10] Durrell, C., *op. cit.*, p. 15.

Muscovite schists, and light-colored muscovite-bearing, but non-schistose rocks derived from rhyolite flows, tuffs, dikes and sills are more abundant in the Lemon Cove schist than in any other division of the Kaweah series, but they represent only a minor fraction of the whole. They are most abundant in the lower part of the section, particularly in the area east of Woodlake Mountain. A few feet above the top of the Yokohl amphibolite there is a metamorphosed rhyolite, evidently a flow about 20 feet in thickness, which is crowded with dipyramidal quartz phenocrysts up to 4 mm in diameter. This flow may be traced through a sinuous outcrop for about 2 miles. It is repeated on the east limb of the syncline which lies east of Woodlake Mountain. Many of the metamorphosed rhyolites are massive and fine grained, and their exact origin is not clear. When schistosity is lacking they may easily be confused with much younger aplite dikes.

A sooty black to silky black garnetiferous biotite-oligoclase schist occurs on both flanks of the Dry Creek anticline, extending from the Homer Ranch to the East Branch of Dry Creek. This rock is believed to represent a metamorphosed slightly alkaline volcanic rock. No comparable rocks have been found elsewhere in the area.

The second most abundant group of rocks in the Lemon Cove schist includes quartzite, and quartz schist. These rocks occur in lenticular masses up to several hundred feet in thickness, and a mile or more in length. Within each lens the rocks are bedded in layers ranging from a fraction of an inch to several inches in thickness. A still finer banding is often present. Between the thicker quartz-rich layers are thin partings of different composition.

These quartz-rich rocks are of two principal types, but all transitions between them may be found. One type contains ferruginous and calcareous impurities represented by such minerals as magnetite, amphiboles, epidote, zoisite, and garnet. The partings between the quartzite layers consist in some cases of thin streaks of magnetite, but more commonly of muscovite-biotite schist representing original argillaceous sediment. Manganiferous beds have been converted to quartz-rhodonite rocks, and manganese oxide stains resulting from weathering are common. Graphite is commonly present and represents original organic material.

These rocks are to be found everywhere in the Lemon Cove schist but are most abundant in the lower part, along the lower course of Dry Creek and westward toward Woodlake Mountain. They are commonly closely associated in the field with amphibolites derived from basalts. The color is most commonly light, but black, purple, and dull reddish-brown rocks are present. Identical rocks are very common in the Yokohl amphibolite in the Rocky Hill quadrangle.

The second rock group is similar in structure, in that it occurs in thin units aggregated into larger lenses. These rocks, however, are micaceous, contain both muscovite and biotite, and constitute micaceous quartz schists. The partings between the larger quartz-rich layers consist of muscovite schist, muscovite-biotite schist or graphite-rich mica schists. Types transitional to these two groups contain both amphiboles and mica.

These rocks are, in their larger aspects and occurrence, similar to the radiolarian cherts of the Franciscan[11] of the Coast Ranges of California, and there can be little doubt they were originally like them in all respects including their origin.

Plagioclase amphibolites and hornblende schists derived from basalt flows and tuffs are abundant in the Lemon Cove schist, particularly along the lower course of Dry Creek, and westward to Woodlake Mountain. In many places, notably near the mouth of Yucca Creek, finely banded rocks consisting of alternating bands of hornblende-rich and plagioclase-rich amphibolites are abundant. These are metamorphosed interbedded basaltic tuffs and impure limestones. Phenocrysts and amygdules may often be recognized among the rocks representing flows.

Marbles derived from limestone are not abundant in the Lemon Cove schist, but occur in all of the three principal areas. A single thin bed, exposed on both flanks of a minor syncline, occurs east of the lower course of Dry Creek and at the Kaweah quarries. The most extensive limestones in the Lemon Cove schist occur along Dry Creek from a mile south of Elder Creek to the northwestward. These have suffered strong contact metamorphism. A few thin and impure limestones occur along Sheep Creek and the North Fork of the Kaweah. Where least metamorphosed the marbles are dull gray and fine grained, thinly bedded and quite impure. More intense alteration results in a coarsening of the grain and lightening of the color, which eventually becomes white. Micas and tremolite result from the recrystallization of impurities.

The thickness of the Lemon Cove schist is about 8000 feet, but almost half of this is thought to be equivalent to the upper part of the Yokohl amphibolite.

Homer Quartzite

The Homer quartzite is younger than the Lemon Cove schist and rests conformably upon it. This division of the Kaweah series consists largely of quartzite and quartz schist derived from chert. Thick and extensive lenses comprised of many thin beds are separated by larger units of mica schist and phyllite, often rich in graphite. In detail these rocks are like those of the second group of quartz schists derived from the cherts described herein under the Lemon Cove schist; only minor amounts containing calcareous and ferruginous impurities are present. Much of the rock between the larger quartzite lenses is also quartz-rich and much of it is rich in graphite. These rocks represent pelitic clastic sediments and siliceous and organic shales.

Mica schists derived from silicic tuffs are far less abundant than in either the Lemon Cove schist or Three Rivers schist, but do constitute an important part of the unit. In the Bear Mountain area such schist becomes the dominant type: the quartzites lens out in that direction. Here the Homer quartzite resembles both the Lemon Cove schist and the succeeding Three Rivers schist, but is neither so rich in amphibolite as is the former, nor in marble as is the latter.

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[11] Davis, E. F., The radiolarian cherts of the Franciscan group: California Univ., Dept. Geol. Sci., Bull., vol. 11, pp. 235-432, 1918.

Muscovite schists derived from rhyolites and rhyolite tuffs occur as thin beds in the Homer quartzite.

Amphibolites, probably mostly derived from basaltic tuffs, are relatively rare.

Marbles occur only in a few thin and short beds.

The thickness of the Homer quartzite is about 7000 feet.

Three Rivers Schist

The Three Rivers schist comes into contact with the Homer quartzite for only a short distance and there it is seen to overlie the Homer. However, the larger portion of the unit as seen along Sheep Creek and on the north side of Sheep Ridge is believed to be equivalent to the Homer quartzite. The detached areas in the vicinity of Three Rivers are correlated with the main body to the north on the basis of lithologic similarity and position.

The rocks of the Three Rivers schist need not be described in detail as they are identical to those of the Lemon Cove schist. They differ, however, in relative abundance.

The most abundant rock type is mica schist derived from silicic tuffs intermixed with fine sediments. These are mostly banded and gneiss-like due to greater intensity of metamorphism than is attained in much of the Lemon Cove schist.

The second most abundant rocks are the marbles and various contact metamorphics derived from pure to impure limestones. A few of these are shown on the accompanying map, but not all were mapped.

Quartzites, muscovite schists, and amphibolite are far less abundant than in the Lemon Cove schist. Mica-rich schists derived from argillaceous sediments, while not constituting a large fraction of the unit, are more abundant than in the Lemon Cove schist.

The thickness of the Three Rivers schist is about 10,000 feet, but very likely the lower 7000 feet is equivalent to the Homer quartzite. The original thickness, however, is not known as the top is not present.

Age of the Kaweah Series

The age of the Kaweah series will probably remain unknown until fossils are found in it. The author has carefully searched for them in places most favorable for their occurrence, but none could be found. A Triassic age was suggested [12] on the basis of lithologic similarity to the Mineral King beds, which constitute a roof pendant some 20 miles to the east. The Upper Triassic age of the Mineral King beds was established on the basis of fossils found there by the writer and Mr. Henry Lindbloom. They were identified by Dr. S. W. Muller.[13]

Plutonic Rocks

The plutonic rocks, which cover the greater part of the mapped area, range in composition from hornblende gabbro to granite, and minor variants extend to still greater extremes. Variation in composition within individual intrusions is not large except in the hornblende gabbro. The mineral composition and texture are for the most part simple. Satellitic dikes are common.

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[12] Durrell, C., *op. cit.*, pp. 16-20.

[13] Durrell, C., *op. cit.*, p. 17.

Two divisions have been made in mapping these rocks. The distinction is based on the presence or absence of quartz in essential amounts, and color may generally be used as an index of the amount of quartz present. Rocks which contain no quartz, or only minor amounts, are dark colored; whereas those with essential quartz are light colored. The first group is designated as hornblende gabbro, and the second as quartz-bearing plutonic rocks.

The area of plutonic rocks is comprised of a number of relatively small intrusions. While the quartz-bearing intrusions have not been subdivided in the mapping, at least eight separate bodies are known. Their approximate distribution is mentioned below.

Hornblende Gabbro

Six distinct bodies of hornblende gabbro are shown on the map. The small area south of the East Branch of Dry Creek is to be considered as a part of the larger body to the north and east of it. Each of the six bodies is probably a separate stock; with the exception of the area in the extreme northwest which extends beyond the limit of the map, and which is known to be complex.

Each of the several bodies exhibits many textural varieties. Rapid variation in grain size is a characteristic feature, the grain size ranging from medium to very large, single crystals of hornblende reaching a length of 6 or 7 inches in pegmatitic facies. Variations in the habit of the hornblende, which is sometimes needlelike, sometimes prismatic, and sometimes equidimensional, produce other varieties. A coarse banded structure, produced by alternations in grain size and texture, is widespread.

The relative amounts of hornblende and plagioclase vary widely and are subject to variation in thin bands. Minor dioritic facies are often very light colored. Hornblende increases to become the sole constituent in many places. Augite, hypersthene, and biotite are common accessory minerals. Quartz is present in small amount in many specimens; olivine has not been detected in any specimen.

Quartz-Bearing Plutonic Rocks

Most of the area is comprised of quartz diorite. Quartz monzonite is second in abundance, and granodiorite occurs only in small amount. Granite is represented only in the eastern border area.

With the exception of one body of quartz diorite, all are very light colored, except in minor border facies, and are rich in quartz.

The large area on the western border of the map, west of Dry Creek and south of Bear Mountain, is mostly light-colored biotite-quartz diorite. Granodiorite occurs along the eastern margin near Dry Creek, and pyroxene-quartz diorite occurs along the west side. Whether this is a complex of intrusions, or whether these variants are only facies of the biotite-quartz diorites, is not known.

The Shadequarter Mountain area consists predominantly of a rather coarse hornblende-biotite-quartz diorite. Local increases in potash feldspar give rise to granodiorite, but this seems to be only a facies difference.

The area southeast of Manikin Flat and extending across the Kaweah River to Horn Mountain and Cahoon Mountain is also hornblende-biotite-quartz diorite.

The Ash Peaks-Yucca Mountain area consists of a coarse-grained biotite granite, but this is separated from the metamorphic rocks by an elongated body of medium-grained biotite-quartz monzonite. This body widens toward the north to include Burnt Point; on the south it includes and extends south of Shepherd Peak.

The area west of Three Rivers, which extends northwestward across Greasy Creek, is composed of two intrusions. The contact between them strikes northwestward and divides the area into two approximately equal portions. Both bodies extend southeastward across the Kaweah River, but their extent in this direction is unknown. The body on the northeast is a rather dark-colored augite-hypersthene-biotite-hornblende-quartz diorite. The southwestern part of this area is composed of a light-colored gneissic biotite-quartz monzonite with conspicuous accessory red garnet.

To the north, east, and south of Lemon Cove is quartz diorite.

Satellitic Dikes

The margins of the plutonic bodies are zones of dike injection. Most of the dikes have essentially the same composition as the adjacent bodies. Differentiated dikes are quite abundant but are simple in composition. Aplite, lamprophyre (malchite and kersantite), and pegmatite dikes occur in both the plutonic rocks and the metamorphic rocks. Aplites are conspicuous, but lamprophyres weather so easily that they are seldom seen. The pegmatites are small and simple in composition and consist almost entirely of quartz, feldspar, biotite, muscovite, and tourmaline.

STRUCTURAL GEOLOGY

The geologic structure of the region is the result of two different processes acting at two different times. Both are consequences of orogeny, and the time difference is small with a possible overlap. The earlier structures are internal to the Kaweah series, and resulted from the compression of the sediments and igneous rocks comprising it. The second set of structures resulted from invasion by the plutonic igneous bodies; they are in part dependent upon the earlier structures.

Structures Internal to the Kaweah Series

The determination of structure in this region was a matter of considerable difficulty for many reasons. Steep dips and local overturning combined with pronounced hill creep and thick soil lend difficulty to the determination of attitude. No original structures were found to assist in a proper determination of position. Lenticularity, lack of distinct horizons, and absence of fossils made it necessary to determine structure and stratigraphy together; neither problem could be independently solved. Lack of continuity due to igneous invasion, and the varying intensity of metamorphism are further difficulties. For these reasons, the structural picture presented may not be the true one, though the principal features are certain. The stratigraphy may be in error to the same extent as the structure. The reasoning which has lead to the present concept has been fully presented elsewhere,[14] and is not repeated.

Steep dips, mostly 70° to 90°, are the rule, and local overturning occurs. In spite of the closeness of folding, there are apparently no large overturns. Small-scale folding is not common except in the immediate vicinity of the axes of the major folds. Here the beds are usually bent sharply back, or are closely plicated in a series of folds with amplitudes of only a few feet, within a zone only a hundred feet in width. The limbs of the great folds are strikingly uniform in dip, and lack minor folds and plications.

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[14] Durrell, C., *op. cit.*, p. 20.

Immediately east of the lower course of Dry Creek is the axis of the Dry Creek anticline which plunges north at a low angle. Puckering of the beds in the axial region may be seen at a number of places.

West of the Dry Creek anticline is a small syncline, determined through the mapping of a marble lens, shown on the map. The dip of the marble lens is steep, even at the south end where it closes about the end of the syncline.

East of Woodlake Mountain is a small syncline determined by mapping a meta-rhyolite flow. The failure of the Yokohl amphibolite to be repeated on the east limb of this syncline is the reason for the assumption of equivalence between the upper part of that unit and the lower part of the Lemon Cove schist. The latter contains a number of amphibolites derived from basalts in that part of the section.

The region between these two synclines is an area of crumpling, apparently representing the region of convergence of a number of large folds now lost through granitic invasion.

South of the Buzzards Roost, in the Lemon Cove schist, is an anticlinal nose, en echelon with the Dry Creek anticline, which plunges south. This fold is immediately cut off on the north by an igneous contact.

A syncline shown in the Bear Mountain area is predicated on very poor evidence.

Along Sheep Creek is an anticline in which beds believed on lithologic grounds to be the Lemon Cove schist are exposed. To the northeast of this, through Sheep Ridge, is a syncline which brings the Lemon Cove schist to the surface farther to the northeast.

Between Sheep Creek and Dry Creek there must be a synclinal axis, but igneous rocks occupy almost all of that region. Where the metamorphic rocks do continue across, contact metamorphism is so intense that no conclusive evidence could be obtained.

The detached areas to the northwest and southeast of Three Rivers are folded, but nothing is known of the structural details.

No evidences of important faulting have been found, but in view of the necessity of determining structure and stratigraphy together, faulting may have passed undetected. Several small faults forming the locus of deposition of quartz veins are present, but these are probably later in age than the main period of deformation during which the folded structures were produced.

Structural Relationships of the Plutonic Intrusives

The contacts between the several plutonic bodies have not been mapped, except for the boundaries of the hornblende gabbro. From the descriptions previously given, however, it is apparent that the form of these bodies, in plan, varies from roughly elliptical to elongate. The hornblende gabbros are the earliest members of the series, as dikes of quartz-bearing plutonics cut them at all contacts, and angular inclusions of the former occur in the latter. The latter fact shows that the hornblende gabbros were solid before the intrusion of later members. Whether or not this is true for all members of the series is unknown. Meager evidence suggests that the sequence, begun with hornblende gabbro, which is the most basic member, progressed toward the more silicic end with the passage of time. This is in agreement with the observations of Knopf [15] and of Mayo [16] for the eastern Sierra Nevada. No evidence of chilling at the contacts has been found.

The contacts between the Kaweah series and the plutonic intrusives may be seen on the map to be partly dependent upon structures within the Kaweah series. The general elongation of the intrusions parallel to the strike of the metamorphics was undoubtedly developed under the influence of bedding and cleavage. On the other hand, the plutonic contacts truncate both anticlinal and synclinal folds, and for large distances contacts cross the bedding at high angles. From this it is clear that intrusion post-dated folding, and that the Kaweah series was not further deformed as a result of intrusion.

The contacts as placed on the map are in part arbitrary, and represent a border zone of injection. The metamorphic rocks usually are intruded by apophyses or dikes for a distance up to a quarter of a mile. These minor injections are mostly parallel to the bedding and schistosity, or at about right angles to it in a steeply dipping plane. The plutonic bodies in the zone adjacent to the contact contain abundant inclusions of the metamorphics, and many of these reach dimensions of hundreds or even thousands of feet. It is thus impossible to delineate an exact contact between igneous rock and metamorphic rock in place.

With minor exceptions actual surfaces of contact between the two rock types are sharp. Due to the complex character of the contact region, contact surfaces may have any attitude.

Examination of the contact zone through a vertical range of several hundred feet shows that the contacts in general dip steeply under the metamorphics, and this is clearly shown on the map. Most contact zones dip at about 65°, and the extreme range is from 45° to 70°. The floor of the roof pendant is nearly flat, however, and the change from dipping wall to flat-lying floor seems to be abrupt.

The flat-lying floors of the metamorphic bodies are exposed in many places, notably in the vicinity of Three Rivers and about Antelope Valley. These relationships are shown on the cross-sections. Plutonic bodies at no great depth are elsewhere indicated by contact metamorphism at relatively great distances from exposed contacts.

The character of the contacts as described above indicate that the plutonic rocks were emplaced by stoping, but local zones of intrusion breccias and injection gneisses indicate that assimilation may have played a part in the emplacement process at an earlier time.

METAMORPHISM

The character of the metamorphism and the metamorphic rocks has been fully presented in the author's earlier work on this district,[17] and will not be repeated herein.

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[15] Knopf, A., and Kirk, E., A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada: U. S. Geol. Survey, Prof. Paper 110, p. 72, 1918.

[16] Mayo, E. B., Some intrusives and their wall rocks in the Sierra Nevada: Jour. Geology, vol. 43, p. 679, 1935.

[17] Durrell, C., *op. cit.*

The metamorphism can best be treated under two headings: dynamothermal metamorphism, the result of stress and elevated temperature; and contact metamorphism, resulting from heat from the intrusive plutonic bodies. The latter usually followed and was superimposed upon the former. It has been shown by the author, in the work cited above, that the two types of metamorphism are, in this area, not clearly separable, and are, in fact, different manifestations of a single set of phenomena. It is believed that the heat involved in both types of metamorphism was derived from the plutonic intrusives, and that where it was effective in conjunction with residual orogenic stress, dynamothermal metamorphism resulted. Where the heat acted in the absence of stress, contact metamorphism in the strict sense was produced. The latter situation was largely dependent upon the form of the magma bodies. Superposition of contact metamorphism upon dynamothermal metamorphism came about with the passage of time through enlargement of the magma chambers.

Greatest emphasis is placed upon the contact metamorphism because of the economic importance attached to it. Recent discoveries of scheelite, one of the principal ore minerals of tungsten, in the zones of contact metamorphism of this area have led to new activity and interest in the district.

Dynamothermal Metamorphism

The rocks of the Kaweah series already described are the result of dynamothermal metamorphism. These constitute the greater part of the Kaweah series, and are modified to a greater or lesser extent by contact metamorphism only along the margins of plutonic bodies. The antecedents of each rock type produced by the dynamothermal metamorphism have been indicated.

Recrystallization under stress and increased temperatures has resulted in schistosity, which is best developed in rocks capable of yielding micas or micaceous minerals in large quantities; but even in these the schistosity is far from perfectly developed. Other rock types are still less perfectly schistose, but the orientation of minerals is evident in most, and can be seen even in some of the marbles.

In general the schistosity is parallel to the stratification and sometimes follows the bedding on crests and troughs of folds. Transgression of the schistosity across the bedding is developed only locally and then in thick, homogeneous, originally incompetent rocks. Such relations may be seen in the mica schists derived from silicic tuffs in the area between Dry Creek and Woodlake Mountain where severe crumpling occurred.

The dynamothermal rocks are all quite fine grained, but the grain size systematically increases as the contacts of the plutonic intrusives are approached.

Contact Metamorphism

The intensity of contact metamorphism varies with the kind of rock and with position. In general, it is most strongly developed along the flat floors of the roof pendants, and at low elevations on the walls of them. The conspicuousness of the contact metamorphism varies with the composition of the rock, being most obvious in carbonate rocks, or in those which originally had a considerable content of calcium carbonate. The contact metamorphic effects gradually fade out with increasing distance from the contact, but generalizations as to the thickness of the contact zone are scarcely possible because of the variation in intensity with position. Along some of the contacts at high elevations, such as those south of Manikin Flat, contact phenomena are almost entirely lacking. Elsewhere the zone of contact metamorphism is several hundreds of feet thick. The width of zone shown on the map is not the thickness of the zone, but is dependent upon that, the dip of the contact, and the topographic configuration within the zone.

In view of the recent economic interest in this area, an approximate outline of the zone of contact metamorphism, where rocks originally limestones are known to be present, is indicated on the accompanying map. Unfortunately, only a few of the carbonate rocks, which are likely to be of economic importance, were mapped, but such rocks may be expected anywhere that the Three Rivers schist is in contact with plutonic rocks, and elsewhere where contact metamorphism is indicated on the map. The limits of the zone as shown on the map are not exact, but will probably include most of the area that is of economic interest, though exceptions are to be expected.

The changes induced in rocks by contact metamorphism are in part structural. The first evidence is usually a hardening of the rock and an attendant loss of cleavage. In some cases, larger, conspicuous crystals appear. In the most intense recrystallization, all trace of schistosity is lost, and the rocks become extremely hard and often flint-like hornfels.

Quartz hornfels, or quartzite, is produced from the quartz schists which often contain visible crystals of graphite.

Feldspar-rich quartz-biotite hornfels is derived mostly from the schists which were originally silicic tuffs. Schists richer in mica yield large crystals of andalusite, and in extreme cases, cordierite-garnet-andalusite hornfels. The last-mentioned type occurs along the South Fork of the Kaweah River near the bridge about a mile southeast of Three Rivers.

The hornblende-plagioclase schists and plagioclase amphibolites develop diopside in contact metamorphism. A few more basic types have recrystallized with the formation of hypersthene and green spinel. In the hand specimen these changes may be detected through the development of a light green color and loss of schistosity. The development of pyroxene occurs first in the more plagioclase-rich portions of the rock. Similar changes occur in the amphibolites derived from gabbro on Woodlake Mountain.

Carbonate Rocks

Originally pure limestones have recrystallized to white marble in which the grain size varies from fine to very coarse. Rocks in which the only impurity was organic material, now contain graphite in thin flakes scattered through the calcite. Rocks of this type are abundant throughout the contact zones of the area, and are often interbedded with rocks of more complex mineralogy.

A marble bed in the Lemon Cove schist along Dry Creek, where it turns northeastward across the metamorphics at the southeast base of Bear Mountain, was originally dolomitic. Scattered through the calcite are crystals of forsterite, diopside, and a little chondrodite. Talc, serpentine, and brucite are present as secondary minerals.

Great diversity of mineralogy is present in the calcsilicate hornfelses derived from impure limestones. A complete list of the minerals and mineral assemblages is given in the publication previously mentioned.[18] The original rock types among this group range from limestones with small amounts of impurities to marls, and highly siliceous rocks which represent replacement cherts. The hornfelses range from nearly pure calcite rocks to those of nearly pure quartz. Intermediate types are various mixtures of calcite or quartz and lime silicates, many consisting largely of the latter. Wollastonite, diopside, grossularite, and plagioclase are the principal lime silicates. Scapolite, idocrase, and zoisite are also present, and their hydrous character indicates the influence of water in metamorphism. Phlogopite is common, usually in rocks originally rich in clay. It is associated with orthoclase and an abundance of diopside. Hornblende is present in rocks representing mixtures of calcium carbonate and basaltic tuff.

Orthoclase, magnetite, pyrite, sphene, and graphite are often present with the lime silicates.

Throughout most of the contact zones of the area, the grain size of these rocks is not exceptionally coarse, and the silicates are disposed in bands often only a fraction of an inch in thickness. Interlaminated bands of nearly pure calcite marble are often present. Such relations indicate clearly that the composition of these rocks has not been changed during the metamorphism. It may be stated with assurance that such rocks were originally impure, and the present banding represents original stratification.

In areas of most intense contact alteration there are rocks in which the grain size reaches dimensions of several centimeters, and all traces of small-scale banding or stratification are lost. Here the metamorphism has probably involved the introduction of such substances as silica and magnesia from magmatic sources. The local occurrence of scapolite, phlogopite, and idocrase, which probably originated under such conditions, may be taken as strong indication of the introduction of chlorine and fluorine. It is not unreasonable to expect the introduction of silica, iron, and magnesia as well, though this has not yet been proven in this district.

Garnet Zones

Among rocks which may have originated in the manner mentioned above are those composed of garnet, epidote, and quartz. Scheelite, the ore of tungsten, is most likely to be found in rocks of this character. Rocks of this type occur locally along the contacts of limestones and plutonic intrusions in several places. They are most strongly developed in the vicinity of Three Rivers. The area immediately east of Three Rivers, including the slopes of the steep mountain known locally as Blossom Peak, contains many outcrops of garnet-rich rocks. South of Three Rivers, on the south side of the South Fork of the Kaweah River, are other occurrences. Similar rocks also occur along the west bank of the Kaweah River opposite Three Rivers.

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[18] Durrell, C., *op. cit.*, p. 58.

Garnet zones also occur along the contact between Shepherd Peak and Advance, and farther to the north toward Yucca Creek. They are less well developed in the valley of Sheep Creek. North and west of the headwaters of Sheep Creek, and extending across to the East Branch of Dry Creek, are numerous outcrops of garnet-rich zones in an area of very intense contact alteration.

Along Dry Creek, for about 2 miles northeast of Elder Creek, and for about 1½ miles south of Elder Creek, the Lemon Cove schist contains several rather thick limestones all intensely altered by contact metamorphism. Garnet-rich zones are not so abundantly developed here as elsewhere, but they are present.

All of the occurrences mentioned above fall within the limits of contact metamorphism as shown on the accompanying map. This discussion is expected to serve only as a general guide and other areas of contact metamorphism should also be examined for possible occurrences of minerals of economic importance.

SUMMARY OF GEOLOGIC HISTORY

The geologic record in this district begins with the accumulation, in a marine environment, of the basic lava flows and tuffs, interbedded radiolarian cherts, and minor clastic sediments that later became the Yokohl amphibolite. This is believed to have been closely followed by the intrusion of sills of diallage gabbro and peridotite. The peridotite was converted to serpentine immediately after emplacement and crystallization.

Basic volcanism waned and was succeeded by the eruption of more silicic volcanic types, chiefly silicic tuffs. Interbedded with the tuffs were fine clastic sediments, cherts, and lava flows, both silicic and basic, and a few limestones. The injection of small dikes and sills accompanied volcanic activity. This series became the Lemon Cove schists.

Deposition of the original cherts and siliceous and organic shales of the Homer quartzite followed the eruption of the silicic tuffs. Volcanic activity became less intense, but both silicic and basic types continued to be erupted. Farther to the east, material later to become the lower part of the Three Rivers schist was deposited contemporaneously. Tuffs, clay-shale, and abundant limestones constituted the principal rocks, but minor amounts of volcanic rocks and cherts were also present. The assemblage representative of the Three Rivers schist succeeded the Homer quartzite farther west. The Three Rivers schist overlies the Homer quartzite along the East Branch of Dry Creek.

Since the age of these marine rocks is unknown, and neither the bottom nor the top of the section is present, the former presence and possible thickness of still younger sediments must remain in doubt.

In the Upper Jurassic, the thick section of sediments comprising the geosyncline out of which the ancestral Sierra Nevada arose, was compressed and tightly folded. The Kaweah series was thereby deformed and recrystallized under stress and increased temperature.

The intrusion of batholithic bodies of plutonic rock followed the completion of the processes of folding, and contact metamorphism occurred at that time as a result of the heat from the magma bodies. Not all of the contact metamorphism was synchronous, for it is clear that the several bodies of magma rose and consolidated serially.

The orogenic episode terminated with the crystallization of the plutonic rocks. No younger rocks other than recent stream gravels are known in this area. Presumably the southern Sierra Nevada has been subject to erosion during the greater part of time since the growth of the ancestral range in the late Jurassic. This long-continued erosion exposed plutonic rocks over the greater part of the area herein described. Only the lowest portion of the once-continuous cover of metamorphosed sediments and volcanic rocks now remains, and even the floors of these roof pendants are exposed in many places. It is along the lower walls, and particularly along the floors, of the roof pendants that the contact metamorphism is most strongly developed. Such regions, where limestones are present, are most likely to contain minerals of economic importance.

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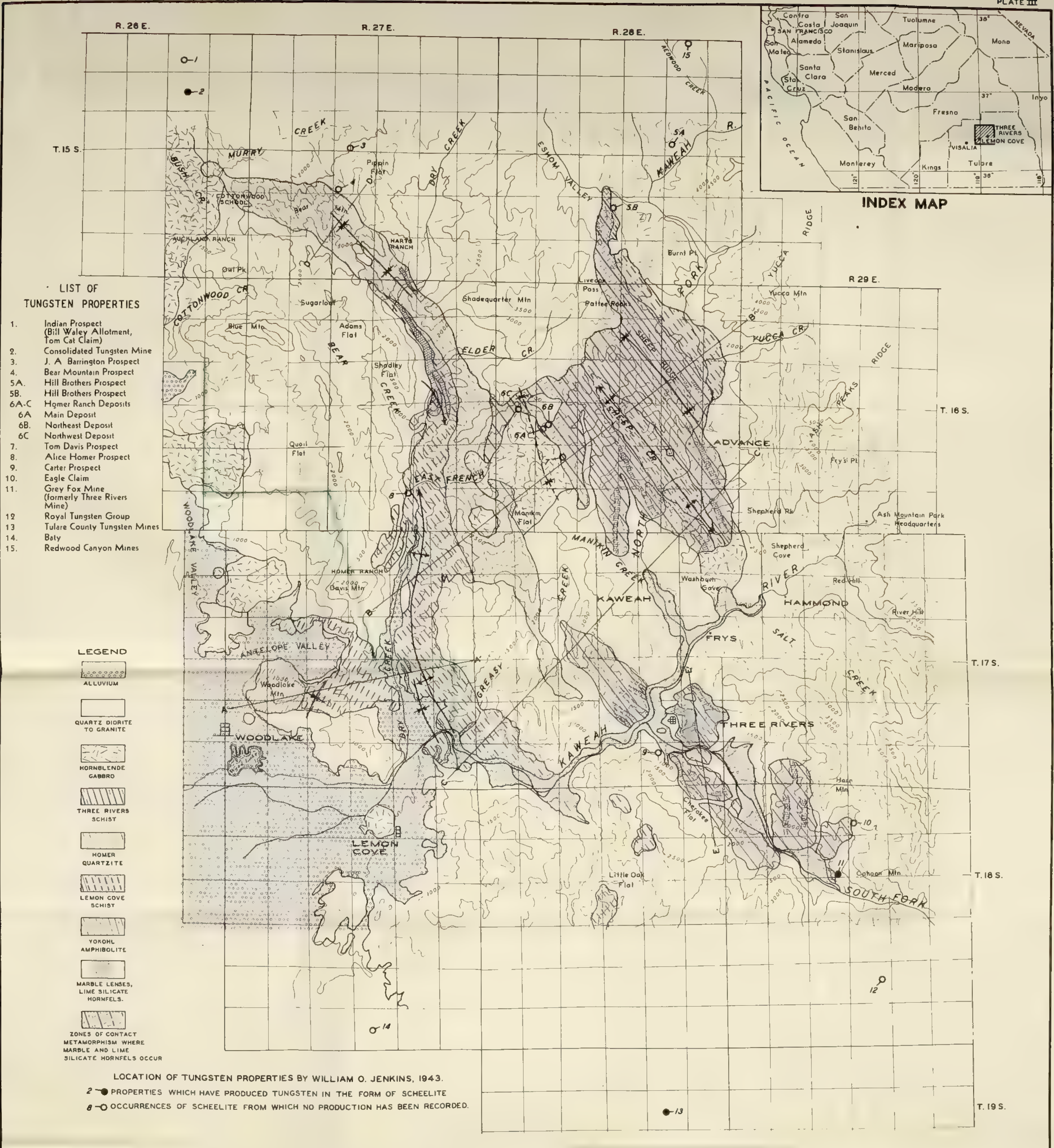
PLATE III


INDEX MAP
Contra Costa
San Joaquin
SAN FRANCISCO
Alameda
San Mateo
Stanislaus
Tuolumne
Mariposa
Mono
NEVADA
Santa Clara
Sta Cruz
Merced
Madera
Inyo
PACIFIC OCEAN
San Benito
Fresno
THREE RIVERS
LEMON COVE
VISALIA
Monterey
Kings
Tulare
38°
37°
36°
121°
120°
119°
118°
R. 26 E.
R. 27 E.
R. 28 E.
R. 29 E.
T. 15 S.
T. 16 S.
T. 17 S.
T. 18 S.
T. 19 S.
MURRAY CREEK
BUSH CR.
COTTONWOOD SCHOOL
BUCKLAND RANCH
Owl Pk
COTTONWOOD CR.
Blue Mtn
Sugarloaf
Adams Flat
Pippin Flat
Bear Mtn
HARTS RANCH
DRY CREEK
ESHOM VALLEY
REDWOOD CREEK
KAWEAH R.
Burnt Pt
Shadequarter Mtn
Live Oak Pass
Rattlesnake Rocks
FORK
YUCCA RIDGE
Yucca Mtn
YUCCA CR.
SHEEP RIDGE
SHEEP CR.
ELDER CR.
BEAR CREEK
Shadley Flat
Quail Flat
EAST FRENCH
Mankin Flat
ADVANCE
ASH PEAKS RIDGE
Frys Pt
Shepherd Pk
Ash Mountain Park Headquarters
Shepherd Cove
MANKIN CREEK
NORTH
KAWEAH
Washburn Cove
RIVER
Red Hill
HAMMOND
River Hill
FRYS
SALT CREEK
WOODLAKE VALLEY
HOMER RANCH
Davis Mtn
ANTELOPE VALLEY
Woodlake Mtn
WOODLAKE
GREASY CREEK
DRY CREEK
KAWEAH
THREE RIVERS
Cherokee Flat
Hawk Mtn
LEMON COVE
Little Oak Flat
Cahoon Mtn
SOUTH FORK
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· LIST OF TUNGSTEN PROPERTIES

1.	Indian Prospect (Bill Waley Allotment, Tom Cat Claim)
2.	Consolidated Tungsten Mine
3.	J. A. Barrington Prospect
4.	Bear Mountain Prospect
5A.	Hill Brothers Prospect
5B.	Hill Brothers Prospect
6A-C	Homer Ranch Deposits
6A	Main Deposit
6B.	Northeast Deposit
6C	Northwest Deposit
7.	Tom Davis Prospect
8.	Alice Homer Prospect
9.	Carter Prospect
10.	Eagle Claim
11.	Grey Fox Mine (formerly Three Rivers Mine)
12	Royal Tungsten Group
13	Tulare County Tungsten Mines
14.	Baty
15.	Redwood Canyon Mines

LEGEND

- ▨ ALLUVIUM
- ☐ QUARTZ DIORITE TO GRANITE
- ▨ HORNBLENDE GABBRO
- ▨ THREE RIVERS SCHIST
- ☐ HOMER QUARTZITE
- ▨ LEMON COVE SCHIST
- ▨ YOKOHL AMPHIBOLITE
- ▨ MARBLE LENSES, LIME SILICATE HORNFELS.
- ▨ ZONES OF CONTACT METAMORPHISM WHERE MARBLE AND LIME SILICATE HORNFELS OCCUR

LOCATION OF TUNGSTEN PROPERTIES BY WILLIAM O. JENKINS, 1943.

2 ● PROPERTIES WHICH HAVE PRODUCED TUNGSTEN IN THE FORM OF SCHEELITE

8 ○ OCCURRENCES OF SCHEELITE FROM WHICH NO PRODUCTION HAS BEEN RECORDED.

GEOLOGIC MAP OF THE REGION ABOUT LEMON COVE AND THREE RIVERS

TULARE COUNTY, CALIFORNIA

BY CORDELL DURRELL

1936

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PLATE IIIA

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SCIENCES
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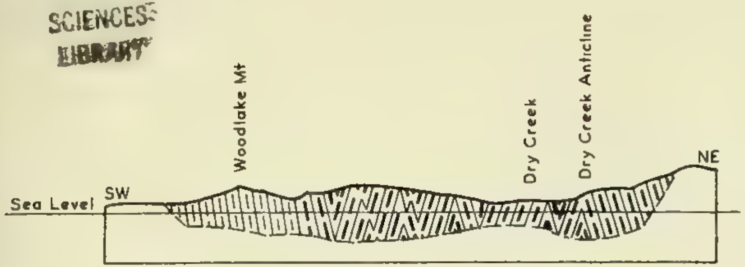
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Dry Creek Anticline
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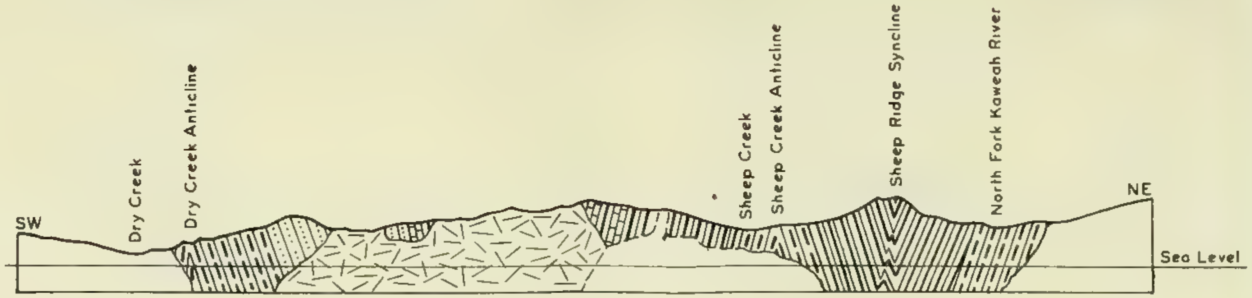
WOODLAKE MT. TO DRY CREEK


Dry Creek
Dry Creek Anticline
Sheep Creek
Sheep Creek Anticline
Sheep Ridge Syncline
North Fork Kaweah River
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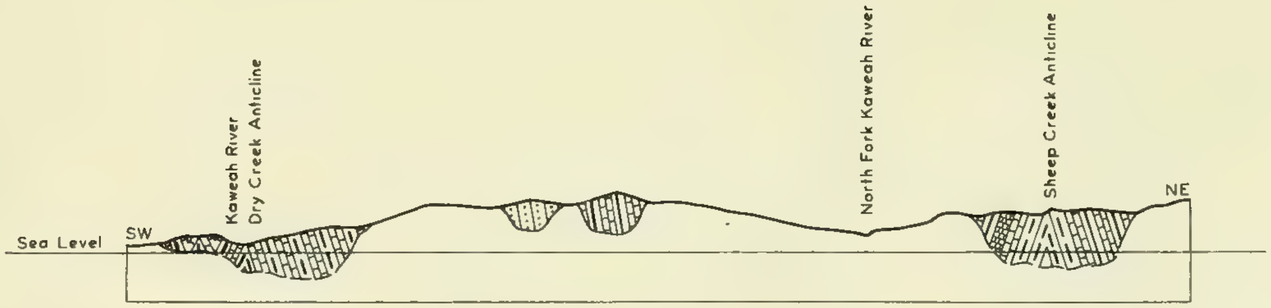
DRY CREEK TO NORTH FORK KAWEAH RIVER


Kaweah River
Dry Creek Anticline
North Fork Kaweah River
Sheep Creek Anticline
Sea Level
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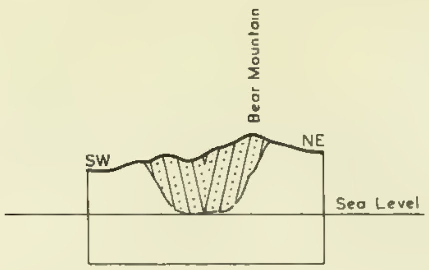
LEMON COVE TO ASH PEAKS RIDGE


Bear Mountain
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GEOLOGIC CROSS SECTIONS

SOUTHERN SIERRA NEVADA NORTHEAST OF VISALIA

CORDELL DURRELL 1936

SCALE
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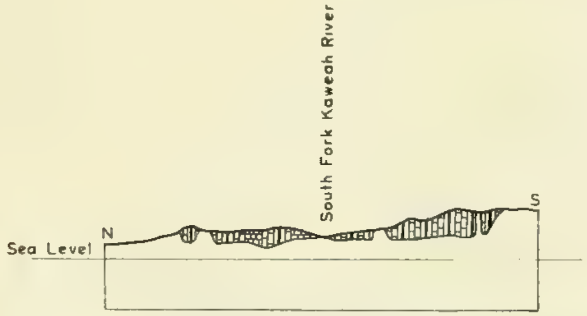
South Fork Kaweah River
Sea Level
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SOUTH FORK KAWEAH RIVER

LEGEND

- ▢ QUARTZ DIORITE TO GRANITE
- ▨ HORNBLENDE GABBRO.
- ▨ THREE RIVERS SCHIST
- ▨ HOMER QUARTZITE
- ▨ LEMON COVE SCHIST
- ▨ YOKOHL AMPHIBOLITE
- ▨ MARBLE LENSES, LIME SILICATE HORNFELS.
- ▨ ZONES OF CONTACT METAMORPHISM WHERE MARBLE & LIME SILICATE HORNFELS OCCUR.

ACCOMPANYING GEOLOGIC MAP (TOPOGRAPHY AND BASE AFTER U S GEOLOGICAL SURVEY. DINUBA, LEMON COVE, TEHIPITE AND KAWEAH QUADRANGLES.)

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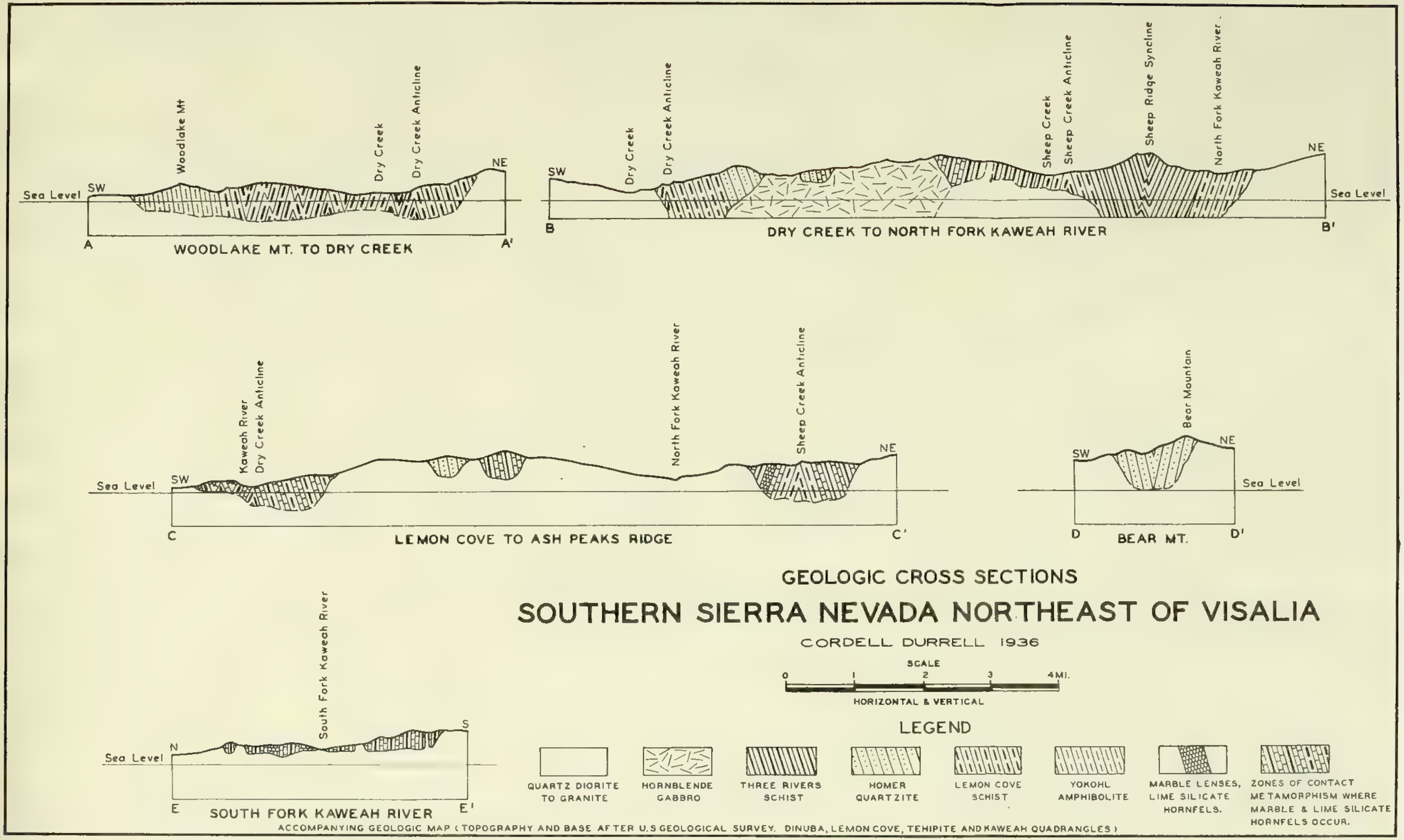
PLATE IIIA


Woodlake Mt
Dry Creek
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Dry Creek
Dry Creek Anticline
Sheep Creek
Sheep Creek Anticline
Sheep Ridge Syncline
North Fork Kaweah River
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DRY CREEK TO NORTH FORK KAWEAH RIVER
Kaweah River
Dry Creek Anticline
North Fork Kaweah River
Sheep Creek Anticline
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LEMON COVE TO ASH PEAKS RIDGE
Bear Mountain
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South Fork Kaweah River
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HORIZONTAL & VERTICAL
LEGEND
QUARTZ DIORITE TO GRANITE
HORNBLENDE GABBRO
THREE RIVERS SCHIST
HOMER QUARTZITE
LEMON COVE SCHIST
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MARBLE LENSES, LIME SILICATE HORNFELS.
ZONES OF CONTACT METAMORPHISM WHERE MARBLE & LIME SILICATE HORNFELS OCCUR.

GEOLOGIC CROSS SECTIONS

SOUTHERN SIERRA NEVADA NORTHEAST OF VISALIA

CORDELL DURRELL 1936

ACCOMPANYING GEOLOGIC MAP (TOPOGRAPHY AND BASE AFTER U.S GEOLOGICAL SURVEY. DINUBA, LEMON COVE, TEHIPITE AND KAWEAH QUADRANGLES)

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TUNGSTEN DEPOSITS NORTHEAST OF VISALIA, CALIFORNIA*

By William O. Jenkins

OUTLINE OF REPORT

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INTRODUCTION

The tungsten deposits northeast of Visalia, California, are part of a belt of deposits that extends from the Havilah and Kern River region in Kern County, through Tulare and Fresno counties, to the northwestern part of Madera County. Scattered deposits of tungsten ore are found in Mariposa and Tuolumne counties and as far north as Grass Valley and Portola.

Most of these deposits are small, although a few have proved themselves quite substantial producers and some others give promise of considerable ultimate tonnage. The ore in a few is high-grade, as the Consolidated Tungsten mine in Tulare County, where "spuds" of sorted ore have been sold as high-grade concentrates without treatment other than crushing. However, this is most unusual, and the ore in the average workable deposit contains somewhere between ½ and 1 per cent tungsten trioxide.

Most of the discoveries have been made within the past 2 or 3 years; before that time, the presence of tungsten ore was virtually unknown over much of this region. Hence, it is to be expected that more discoveries will be made during this year and for as long afterward as the demand for tungsten stimulates the search for ore deposits.

Until recently the problems of concentration and marketing of ore have prevented the development of some of the smaller deposits. There has been no local market for the ore itself, custom concentrating plants are few and far between, and in most cases the small deposit does not justify construction of a mill. Hence many have remained idle.

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* This report has been prepared to supplement the preceding paper by Cordell Durrell, *Geology of the Sierra Nevada Northeast of Visalia, Tulare County, California*. Locations of the tungsten deposits described have been plotted on the geologic map accompanying Durrell's report.

Manuscript submitted for publication June 8, 1943.

However, recently (April 1943) Metals Reserve Company has established an ore purchase depot in Fresno, where ore in small lots is purchased from the mines. Already this has resulted in renewed activity of some of the small mine operators, who are hauling their ore to Fresno.

Mining operations in the area northeast of Visalia should be considerably stimulated, for the ore purchase depot is within economical hauling distance of this area.

GEOLOGY OF THE DEPOSITS

All occurrences of tungsten in this area are found in contact-metamorphic zones. The ore mineral, scheelite ($CaWO_4$) is present in tactite which has been formed by the alteration and replacement of limestone adjacent to granitic intrusions. The tactite is made up chiefly of garnet, epidote, and quartz, and minor amounts of calcite and other minerals. The scheelite and quartz are generally associated with each other and appear to have been introduced into the matrix of garnet and epidote.

Where thick lenses of limestone have been replaced with tactite only along their borders, adjacent to the granitic contacts, it may be shown that the formation of tactite has taken place along bedding planes, joint planes, and fractures. Where such openings have not existed, the limestone is affected only by a complete recrystallization, the end product in these cases being a white, or gray and white, banded, usually coarse-grained marble.

Small limestone lenses along the contacts of roof pendants and small, isolated pendants composed wholly of limestone are often completely replaced with the tactite minerals.

Distribution of scheelite is characteristically very erratic, although in some cases it has been evenly disseminated throughout small layers of tactite. Scheelite may be deposited along relict bedding planes, joint planes, or in any fractures or brecciated areas or other openings that existed in the mass at the time of introduction of mineralizing solutions. There are very few cases where scheelite has been deposited in the granite itself, in the marble, or in adjacent schistose rocks, and even where such occurrences have been noted, the mineralization is extremely limited in extent.

In general, the formation of tactite is limited to granite-limestone contacts, whether the limestone be a part of a large pendant or a belt of metamorphic rocks, or a small, isolated pendant completely surrounded by granitic rock; or whether the granitic rock be a part of the main granitic intrusion or a relatively narrow dike or apophyse.

Field observations in this and other areas indicate that in many cases, scheelite mineralization is more closely related to undifferentiated border dikes, satellitic dikes, and pegmatites than to the main intrusive mass itself.

PROSPECTING FOR SCHEELITE

The area northeast of Visalia has so far been incompletely prospected. Few prospectors are or have been active in this area, although some tungsten deposits have been discovered here within the past 2 or 3 years. Prospecting is easier here than in many areas, for most of the region is quite readily accessible and the climate is such that work can be carried on at any time of year. The chief criteria, the limestone-granite contact and the tactite outcrop, are easily recognized. Soil cover is in general thin and outcrops are plentiful.

First, one should not lose sight of the fact that the presence of tactite does not necessarily mean the presence of scheelite in any quantity. Although many of the garnet-studded outcrops are rich in scheelite, others are barren, or nearly so. They must be examined carefully with the ultra-violet lamp before positive assurance may be had of the presence of scheelite ore.

Prospecting should be carried on in a systematic manner. The geologic map should be consulted and a likely area chosen. One should go over this area thoroughly, following the limestone contacts and investigating carefully any occurrences of tactite either as float or in place. A large black cloth may be carried to serve as a darkroom under which to observe the suspected rocks. A piece of black sateen is very satisfactory for this purpose. It is fairly light-proof and has the added advantages of being both inexpensive and light in weight. It should be at least 6 feet square.

The location of any occurrence of scheelite ore should be carefully marked and returned to at night for further investigation with the ultra-violet lamp, for it is only at night that a thorough examination with this instrument can be made satisfactorily. During the daylight hours, even when a black cloth is used, it is very easy to miss the best part of a showing, for the field of view is limited to a small area under the cloth.

There are several makes and models of ultra-violet lamps on the market that are quite satisfactory for prospecting. Too much weight is to be avoided, but weight should not be eliminated at the expense of efficiency. Prospecting is hard work at best and its results should not be jeopardized by the use of an inefficient lamp.

The value of the pick and shovel must not be overlooked. The deposit may be covered with rock and soil overburden and its position indicated only by the presence of tactite float on the hill slope below. A few hours of digging may uncover a good showing of tungsten ore in place. Even where the tactite is exposed in an outcrop, its width and length may be extended considerably by the judicious use of the pick and shovel.

It is always wise, and generally more economical in the long run to check field estimates of grade of ore against assays. One or more samples which under the ultra-violet lamp look representative of the deposit should be taken to a competent assayer for determination of tungsten trioxide content. If a yellow fluorescence is displayed, determination of molybdenum content in concentrates should also be made. It is unwise to rely entirely upon the lamp for estimating grade. No two deposits are alike and although the prospector may become accustomed to estimating ore grade in one deposit with the lamp, he may find his estimates either too high or too low when examining ore from another deposit. After a few check assays have been made, it is much easier to estimate the tenor of ore with the lamp alone.

After the presence of an ore deposit has been established, it is natural to begin to think in terms of possible tonnage. Estimating tonnage of ore in these deposits, even where exposures are good, is a hazardous undertaking. The erratic shape of the typical tactite body, its characteristic lack of continuity and lenticular nature inherited from the limestone body, together with the usual hit-or-miss distribution of scheelite, make accurate estimates impossible. But since this difficulty presents itself throughout the life of the mine, and since some sort of estimate must be made, some method of tonnage estimating must be used.

It is unwise to project ore very far beyond visible limits, or to assume that all the tactite is ore. A careful examination of the outcrop with an ultra-violet lamp will give some idea of the distribution of scheelite within the tactite and from this a tentative percentage factor may be arrived at which can be applied to the overall tonnage estimate, converting tactite tonnage to ore tonnage.

The figure of 12 cubic feet of ore in place to the ton is generally safe to use, although some ore is somewhat heavier than this.

DESCRIPTION OF DEPOSITS

General Discussion

Following is a list of tungsten deposits situated in the area northeast of Visalia, together with descriptions of the individual deposits. These are numbered and the locations and numbers have been plotted on the geologic map by Durrell, which precedes this article. A study of this map will demonstrate the relationship between distribution of the deposits and marble-granite contact areas.

No such list as this may be considered to be in any sense complete. Undoubtedly deposits have been discovered which have not been reported to the writer and hence do not appear here. It is hoped that even if the list is complete as of the date of its compilation, it will not long remain so, and that many more discoveries will be made in this area.

[1](1) Indian Prospect (Bill Waley Allotment, Tom Cat Claim)[2]

Location: W$\frac{1}{2}$ sec. 2, T. 15 S., R. 26 E., Tulare County, on north side of Drum Valley, elevation 2000 feet, about a mile north of Harrell Hill mine, Dinuba quadrangle.

Several prospect holes have been sunk here in past years, presumably in search of minerals other than scheelite. One open cut 25 feet long, dug at an undetermined date, exposes the tungsten ore.

The property was located as the Tom Cat mining claim in November 1941. However, since this property is part of an Indian allotment, the claim was invalid. Property was leased early in 1943 by the Indian Service to Strickland and Appleby, Exeter, who turned it over to the present operators, Tyler Jack, Glen Henry and William Bloyd, of Reedley.

Rather fine-grained scheelite occurs disseminated in tactite associated with coarse-grained white marble over a 3- to 5-foot width for approximately 150 feet along a granite contact which parallels the strike of bedding in the marble. The granite along the contact is decomposed and very friable. The contact strikes N. 75° W., dipping steeply to the north at the open cut, but flattening to the west, toward the end of the deposit, where the deposit is quite shallow and the granite passes under it close to the surface.

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[1] For graphic location of this property and those properties described below, see geologic map by Durrell in preceding report.

[2] Description of this property is by William O. Jenkins and James M. Little.

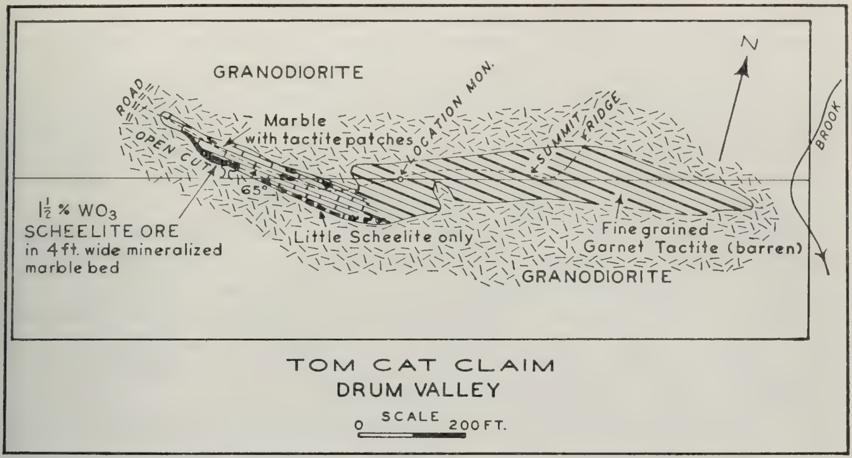
GRANODIORITE
ROAD
OPEN CUT
Marble with tactite patches
LOCATION MON.
SUMMIT RIDGE
N
BROOK
65°
1½ % WO3 SCHEELITE ORE in 4 ft. wide mineralized marble bed
Little Scheelite only
Fine grained Garnet Tactite (barren)
GRANODIORITE
TOM CAT CLAIM
DRUM VALLEY
SCALE
0
200 FT.

FIG. 1. Geologic map of the Indian prospect (Tom Cat claim), Drum Valley, W½ Sec. 2, T. 15 S., R. 26 E., M.D., Tulare County. *Map prepared by James M. Little and William O. Jenkins.*

This deposit occurs at the southwest end of a ridge whose crest, throughout its 700-foot length, is composed of tactite, which in the central and eastern end is light in color, very dense and siliceous, containing no scheelite for the most part, although here and there scattered colors may be observed with the ultra-violet lamp. On the western end of the ridge, however, one finds the typical coarser-grained tactite characteristic of this area, which contains garnet, epidote, and calcite crystals, many of them abnormally large (epidote crystals up to 4 inches long have been observed). A fairly large amount of fine-grained quartz is present, appearing to have been largely introduced with the scheelite, which is disseminated in the tactite as small crystals. The outcrop as a whole is in contact on all sides with granitic rocks and may be considered as a small isolated pendant which has been subjected throughout to strong contact-metamorphic action.

The ore zone is rather porous, containing localized leached zones both in the tactite itself and in the adjoining beds of marble. The tactite is fairly friable, but this is probably due largely to the influence of weathering. Distribution of the contained scheelite was controlled primarily by the position of the granite contact and by the strike of bedding in the marble, while minor cross-fractures and jointing appear to have exercised a secondary control.

At present (June 2, 1943) the operators have started stripping the decomposed footwall granite from the deposit preparatory to mining the exposed ore and further developing the deposit. Development ore will be milled locally or hauled to the Fresno ore-purchase depot of Metals Reserve Company, a distance of approximately 60 miles.

(2) Consolidated Tungsten Mine (Harrell Hill Mine, Dinuba Mines)

Location: sec. 11, T. 15 S., R. 26 E., M. D., Tulare County, on the southeast end of Drum Valley, Dinuba quadrangle. Elevation 2000 feet.

The mine is located on Harrell Brothers ranch land. It was located and leased in 1941 by the Parlier Prospecting Association, who built a road to the outcrops and did some preliminary open cut work, subsequently (February 1942) leasing the property to Bruce McDonnell of Sacramento. A mill was erected on Slick Rock Creek at a distance of about 3 miles from the mine property and ore has been treated and concentrates produced since that time. In the spring of 1943 the property changed hands and is now operated by Consolidated Tungsten. At present (June 1943) the mill is being operated 12 to 16 hours daily and is treating an average of about 35 tons of ore daily.

The deposit consists essentially of a small marbleized limestone pendant in granite, which has been strongly sheared and in which much of the marble has been replaced by tactite, replacement having taken place along bedding planes in the marble and along strong cross-fractures and sheared zones in the pendant. Bedding in the marble strikes N. 50° E., dipping vertically. Scheelite mineralization has been very strong in the upper part of the deposit and is accompanied by quantities of quartz. In the eastern part of the pendant a massive outcrop of quartz may be observed at the surface and although this has not yet been encountered in the underground workings, present evidence indicates its role as a ''feeder'' for the high-grade ore shoots in the mine.

At present the orebody has been developed for a maximum distance of over 200 feet along the strike and to a maximum width of approximately 50 feet. The shape of the orebody cannot be known at present, however, for the ore has been distributed irregularly along the openings in the mass. A maximum depth of ore of 75 feet has been proven, although the ore in the lower level is neither as wide nor as rich as that nearer the surface. Development has been accomplished with lateral openings which follow the ore zones, and with raises. Stopes are timbered with square sets.

Much very high-grade ore has been recovered during the past year from the main ore shoot in the upper level. Many tons of high-grade concentrates have been produced solely by hand sorting in the mine.

Some of the scheelite is fine-grained and disseminated in the tactite, but most of the values have been in extremely coarse-grained scheelite crystals occurring in the fractured zones.

(3) J. A. Barrington Prospect

Location: sec. 16, T. 15 S., R. 27 E., 2 miles southwest of Badger, Tulare County, Dinuba quadrangle.

A considerable amount of prospecting and preliminary development work has been done here by J. A. Barrington during the winter and spring of 1943. Work done to date indicates that the deposit consists of two or more small pods of tactite, completely surrounded by granitic rocks. The maximum length of the largest indicated pod is 50 by 75 feet. The tactite in the surface outcrops and in the open cuts is strongly weathered and contains scheelite distributed along joint planes and fractures and locally disseminated in the tactite adjacent to the igneous contact.

The deposit appears to be the shallow remnant of a limestone pendant, although greater depth and lateral extent may be proved by further development work.

(4) Bear Mountain Prospect

It is reported that operators are going to begin development work on a prospect situated on Bear Mountain, T. 15 S., R. 27 E., east of Auckland Ranch, Dinuba quadrangle. No investigation has been made of the deposit and no further information is available at present. Location uncertain.

(5A, 5B) Hill Brothers Prospects

(*No. 5A*). Location: sec. 14, T. 15 S., R. 28 E., on the northwest bank of the North Fork of the Kaweah River, 3¼ miles east of Eshom Valley School, Tulare County, Tehipite quadrangle. Elevation 3500 feet.

This claim was located by Ed Hill, his brothers and an associate, who live in Eshom Valley. No work has been done to date on the claim except prospecting and location work.

Fine-grained, dark-colored tactite has been formed along the contact of marble and granite. Scheelite, accompanied by some powellite, is disseminated throughout the tactite in small crystals. The bedding in the marble strikes east, standing in a near-vertical position.

On the south side of the deposit, this contact parallels the bedding in the marble, while on the eastern end, a granite embayment cuts off the lens. The richest ore is to be found along this eastern end. Apparently the mineralizing solutions were allowed easier access to the limestone where the truncated ends of the beds were exposed than they were where the contact follows the bedding planes. This condition has been observed elsewhere, as well.

An aggregate total length of ore of perhaps 75 feet, together with an average width of 4 feet is indicated in the outcrops, whose vertical range of distribution on the steep canyon walls is more than 50 feet.

(*No. 5B*). Location: sec. 28, T. 15 S., R. 28 E., 2 miles southwest of No. 1, above, on the south slope of Eshom Creek Canyon. Elevation 3000 feet.

This claim was located by Ed Hill, his brothers and an associate, of Eshom Valley.

This deposit has also been formed along a granite-limestone contact at the northeastern end of a long and broad belt of metamorphic rocks which widens to the south and extends as far as the Kaweah River at Washburn Cove. The tactite is in general coarse-grained and is much weathered. It is largely covered by a mantle of surface soil, the only good exposures being in a crosscut trench which the owners have dug across the outcrop. Little can be said of the extent of the deposit at this writing. However, a width of 10 feet and a length of 40 to 50 feet is not unlikely for the tactite.

(6A, 6B, 6C) Homer Ranch Deposits

The Homer Ranch deposits comprise three separate deposits, all situated on patented agricultural land owned by the Homer family, Lemon Cove, California. A considerable amount of exploration work was carried on here during the fall and winter of 1942, especially on the ''Main deposit,'' by H. W. Thorne, Pasadena, California. At present, the property is idle (June 1943).

No. 6A—Main Deposit. Location: sec. 20, T. 16 S., R. 28 E., Tulare County, Tehipite quadrangle. Elevation 3000 feet.

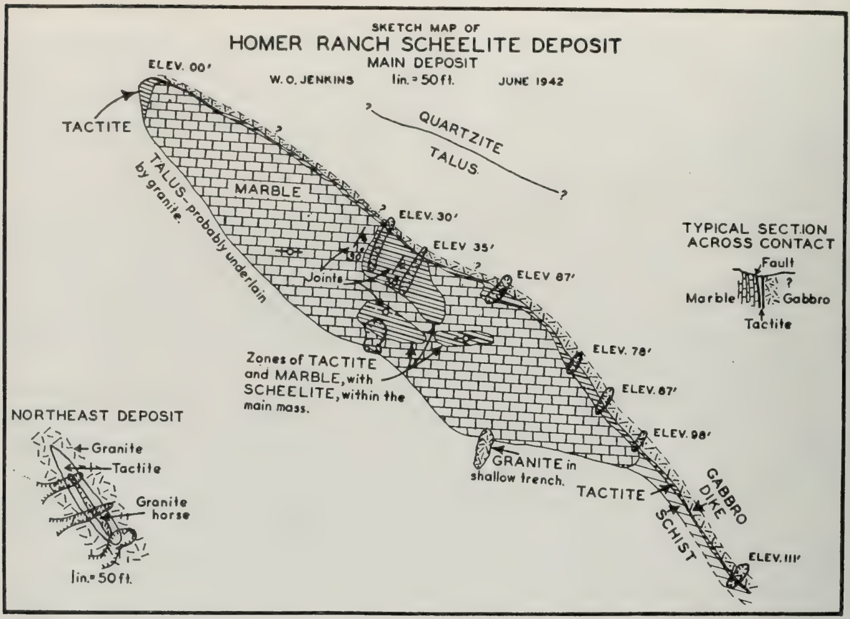
SKETCH MAP OF
HOMER RANCH SCHEELITE DEPOSIT
MAIN DEPOSIT
W. O. JENKINS
1in. = 50 ft.
JUNE 1942
ELEV. 00'
TACTITE
MARBLE
TALUS-probably underlain by granite.
QUARTZITE
TALUS
ELEV. 30'
ELEV 35'
ELEV 87'
Joints
Zones of TACTITE and MARBLE, with SCHEELITE, within the main mass.
ELEV. 78'
ELEV. 87'
ELEV. 98'
GRANITE in shallow trench.
TACTITE
GABBRO DIKE
SCHIST
ELEV. 111'
TYPICAL SECTION ACROSS CONTACT
Fault
Marble
Gabbro
Tactite
NORTHEAST DEPOSIT
Granite
Tactite
Granite horse
1in. = 50 ft.

FIG. 2. Sketch map of the Homer Ranch scheelite deposits.

The scheelite-bearing tactite of the main deposit occurs along the border and within the main mass of a well-defined lens of marble. Roughly lenticular in shape, this lens has a length of 400 feet and an average width of approximately 50 feet. Its direction of elongation is N. 65° W. Bedding, which is well-preserved in the granular, white marble, strikes east and dips vertically.

The southwest side of the marble body is in contact with decomposed granite. Little or no tactite has been formed along this contact and there are no known occurrences of scheelite immediately adjacent to it.

Along its northeastern side, the marble is in contact with a dike of hornblende gabbro. Trenching and stripping of overburden has shown the presence of this rock for the full length of the lens. Along the contact, a narrow zone of gouge and breccia indicates movement. A zone of tactite is present along the full length of this contact. It varies in width from 6 inches to 8 feet and carries medium-grade scheelite ore through most of its extent.

At least three occurrences of scheelite-bearing tactite of irregular outline occur within the main mass of the marble lens. Their distribution is controlled by jointing and bedding in the marbleized limestone. Some very high-grade ore has been found in these zones.

No. 6B—Northeast Deposit. Location: sec. 20, T. 16 S., R. 28 E., Tulare County.

Situated ¼-mile northeast of the main deposit, this deposit consists of a pod of tactite 70 feet long, whose average width is 10 feet. This pod is surrounded by granite and is apparently very limited in size. Ore is in general low-grade.

No. 6C—Northwest Deposit. Location: sec. 19, T. 16 S., R. 28 E., Tulare County. One mile northwest of the main deposit, tactite is exposed intermittently over a distance of several hundred feet. Some of this material shows scheelite with the ultra-violet lamp. It is associated with a lens of marble and is adjacent or close to the contact of a large intrusion of hornblende gabbro. Practically no work has been done here to expose the ore.

(7) Tom Davis Prospect

Location: one mile southeast of main Homer Ranch deposit, in sec. 29, T. 16 S., R. 28 E. Owned by Tom Davis, Woodlake, California.

This deposit is said to be similar to the main deposit of the Homer Ranch. It is situated along the contact of a large body of gabbro and marbleized limestone. The marble lens is 1000 feet long overall and 100 feet wide. Tactite occurs along the gabbro contact and is distributed irregularly in the marble. It is reported that the ultra-violet light shows the presence of a considerable amount of scheelite. No work has been done here.

(8) Alice Homer Prospect

Location: sec. 34, T. 16 S., R. 27 E., on Dry Creek, 8 miles north of Lemon Cove. Owned by Alice Homer, Lemon Cove, California.

A small pod of tactite outcrops here along the contact of a broad belt of metamorphic rocks and granite. The tactite is dense and hard and is a dark-green color. Scheelite is fine-grained and disseminated in the tactite. Exposures are very poor.

A little exploration work was carried on here during the summer of 1942, but there has been no work done since.

(9) Carter Prospect

Location: sec. 35, T. 17 S., R. 28 E., 1 mile southwest of Three Rivers. Owned by Mrs. Carter, Three Rivers.

At the time this prospect was examined, surface work had exposed a few feet of tactite ore in contact with granite. No indications of possible size were given by this work, although the deposit appeared to be another of the small remnants which are to be found scattered through this region. A few tons of ore are said to have been milled from this prospect.

(10) Eagle Claim

Location: sec. 3, T. 18 S., R. 29 E., on the south side of the North Fork of Cinnamon Creek, on Bald Hill, Tulare County, Kaweah quadrangle. Elevation 3000 feet.

This claim was located in December 1942 by Robert Records and Artie Helm, Woodlake. Preliminary prospecting work and location work was done by these men. The claim has now been sold to J. Spitler, C. Tibbals, and F. Adams, Dinuba, and these men are reported to be doing further work to develop the ore.

The deposit is situated on the northeast side of a mile-wide area of metamorphic rocks, along the contact of marble and granite. Several occurrences of tungsten ore have been noted on the mining claim. Scheelite is present in tactite which has been formed adjacent to the granite contact. It is irregularly distributed along sheared zones, bedding, and jointing in the marble. Little work has been done to date, although geological conditions favor the possibility of a deposit of considerable size.

(11) Grey Fox Mine (Formerly Three Rivers Mine)

Location: sec. 16, T. 18 S., R. 29 E., on the west slope of Cahoon Mountain, Tulare County, Kaweah quadrangle.

This property is owned by H. E. Root and Rose Belle Root, who have leased it to William Clinesmith and a partner. Two tunnels have been driven on the property during the past 2 years, by former leasers. Both have exposed some ore. The present leasers have opened up a face of ore 3½ feet wide and 10 feet high. A sample taken across this face assayed 1.05 percent WO_3.

The ore deposit is located on the eastern border of a quarter-mile-long lens of marble, where it is in contact with granite. The strike of the contact roughly parallels that of the bedding in the marble, being N. 15° W., dip vertical. Development work to date indicates that the ore is limited to the immediate contact zone, in a zone 3 to 4 feet wide. However, it is possible that a deposit of considerable width may be developed here, for at intervals along its strike the marble is cut by strong shear zones following cross-fractures, or cross-jointing, which are approximately normal to the granite contact. From observations made elsewhere, it has been noted that this condition is often accompanied by the formation of tactite bodies in the marble for some distance from the igneous contact. The length of the deposit along the strike has not yet been determined, and lack of good exposures makes it impossible to ascertain.

Work is being carried on here at the present writing (June 2, 1943). Eighteen tons of ore have been treated at a local custom mill.

(12) Royal Tungsten Group

Location: sec. 26, T. 18 S., R. 29 E., on west side of Grouse Peak, Tulare County, Kaweah quadrangle. Elevation 5000 feet.

Claims were located in the spring of 1941. They are owned by George W. Hicks and son, John C. Brockman, et al. Work done to date consists of a few small open cuts and one 20-foot pit.

Here an unusually large mass of tactite has been formed along the granite contact of a broad belt of marbleized limestone. The tactite outcrop is very prominent for at least 700 feet along the brow of Grouse Peak, forming a steep bluff. Its average width is 50 feet. The strike of this mass is east, while its dip is quite moderate, being 25° N. Another body of tactite outcrops a few hundred feet to the north; this may or may not be part of the same deposit. In some parts of the mass the tactite is less well developed than in others and grades into areas of impure crystalline limestone.

In spite of the great size of this tactite body, very little scheelite can be seen with the ultra-violet lamp, and this only in localized areas. This is a very interesting condition, for it demonstrates that the factors necessary for the formation of a body of tactite are not identical with those responsible for the introduction of scheelite into that mass, and emphasizes the absolute necessity for thorough prospecting with the ultraviolet lamp after the tactite itself has been discovered.

In the spring of 1943, no more work had been done here, although the owners signified their intention of exploring the deposit further.

(13) Tulare County Tungsten Mines

Location: sec. 11, T. 19 S., R. 28 E., on Will Gill Ranch property, 14 miles east of Lindsay. The mine is in Tulare County, Kaweah quadrangle. Elevation 2300 feet.

This mine property is owned by the Will Gill Ranch and is leased to Tulare County Tungsten Mines, who have been mining and milling here since early 1942. A very substantial tonnage of medium-grade ore has been developed and the milling capacity has been increased to about 100 tons per day.

The deposit is contact metamorphic and the scheelite, in general rather fine-grained, is disseminated in tactite. The tactite bodies lie between granite and a fairly broad belt of metamorphic rocks—schist and crystalline limestone—which have a nearly vertical attitude and strike in general N. 15° W., although there is considerable local deviation from this course.

Mineralization appears to be strongest adjacent to the granite, although formation of tactite and deposition of scheelite have taken place for a distance of some 50 feet from the contact. Within this zone, schist layers are present, indicating a pre-mineral condition of alternating beds of schist and limestone. A rather intensely sheared zone adjacent to the granite contact has resulted in a porous mass which has allowed mineralization to take place over a wider zone than may be considered usual for this region.

Mining is being carried on by open-cut methods and ore is hauled by truck to the company's mill, 1½ miles distant.

(14) Baty Mine

Location: sec. 34, T. 18 S., R. 27 E., about 1½ miles southeast of Lind Cove. Elevation 700 feet.

Property is owned by Wm. Meherten and leased by S. P. Baty, Exeter. The deposit has been developed by one 15-foot shaft and an open cut 40 feet long.

Moderately dipping beds of marbleized limestone are faulted against steep-dipping mica schist, producing a porus zone which is cut off by a granite embayment. Coarsely crystalline scheelite is associated with a strong quartz mineralization near the granite contact. The mineralized zone extends along the marble-schist fault contact for at least 60 feet from the granite, and indications are that mineralization continues for some distance back into the marble, along the bedding planes and adjacent to the granite contact where it truncates the marble lens. Light-colored tactite has been formed throughout the mineralized zone.

Mr. Baty has already shipped a small amount of ore and is operating the property at present (June 2, 1943). He will probably haul ore to the Metals Reserve Company ore-purchase depot in Fresno.

(15) Redwood Canyon Mines

Location: sec. 2, T. 15 S., R. 28 E., in Redwood Canyon, Tulare County. Elevation 5250 feet.

The group of claims now known collectively as Redwood Canyon mines, is owned by Edith F. Barton, et al., Badger, California. It has been leased to M. C. Richardson and Edward Homer, both of Lemon Cove, California. These men have started development of a tungsten orebody recently found on the Lamb Mine claim, at the northwest end of the Redwood Canyon group. Preliminary sampling and development work have shown the presence of high-grade scheelite ore in an orebody of undetermined size.

The Lamb Mine claim is located along the strike of one or two or more roof pendants of calcareous metamorphic rocks, in granitic intrusives. The pendants parallel each other and may be traced by means of discontinuous exposures for a distance along the strike of more than a mile. At several points along these pendants, mineralization has occurred and ores of tungsten, copper, and some silver and gold have been found.

The strike of bedding in the roof pendants is N. 35° W. and the dip from 55° to 80° SW. It has been impossible, because of poor exposures, to determine thickness and continuity of the metamorphics. A heavy covering of detrital material is general in this rather heavily forested area.

In the vicinity of the Lamb shaft, open cutting has exposed a 45-foot thickness of tactite. However, the full width is not known, for the contacts have not been exposed. Near the center of this exposure is a mineralized bed of tactite, apparently occupying a shear zone in the garnetiferous rock. The zone is from 5 to 6 feet thick and is well exposed in the uppermost 15 feet of the shaft.

For a distance of about 12 feet below the surface, the ore zone is thoroughly leached and very porous. Secondary calcite has been deposited in the openings. Little scheelite is to be found in this zone. However, in the shaft, at a point 12 feet below the original surface, high-grade scheelite ore occurs in the tactite.

There is evidence of secondary deposition of scheelite at the bottom of the leached zone in the friable, decomposed tactite. Whether this is deposition by chemical or mechanical means is not known, but it seems logical to assume it to be mechanical, at least in part. The scheelite, which is very fine-grained and disseminated uniformly in the tactite, could not have remained in suspension on the porous, leached upper part of the orebody after the soluble material in the gangue was removed by solution, and could readily have migrated downward mechanically until arrested by the dense primary tactite ore. The nature of deposition suggests strongly that such a process has taken place.

Scheelite in the primary ore below the leached zone is in general very fine-grained. Its distribution on the tactite is remarkably uniform. The exposed ore is high-grade, assaying from 3 to 10 percent WO_3. Gangue minerals are calcite, quartz, epidote, and garnet. The ore is very hard and dense and contains small amounts of iron and copper sulphides.

Under the ultra-violet lamp, most of the scheelite fluoresces with a golden color, presumably because of the presence of some powellite, which is known to occur with the scheelite here to some extent.

The hanging wall of the ore zone is composed of dense, brown tactite, containing a predominance of garnet. There is a 30-foot width of this, at least, as exposed in the open cut. For the most part, this zone is barren of scheelite. It is thick-bedded to massive and has the same dip and strike as the ore zone.

Footwall material is iron-stained, decomposed, soft tactite, containing some scheelite adjacent to the ore zone, but barren a few feet away

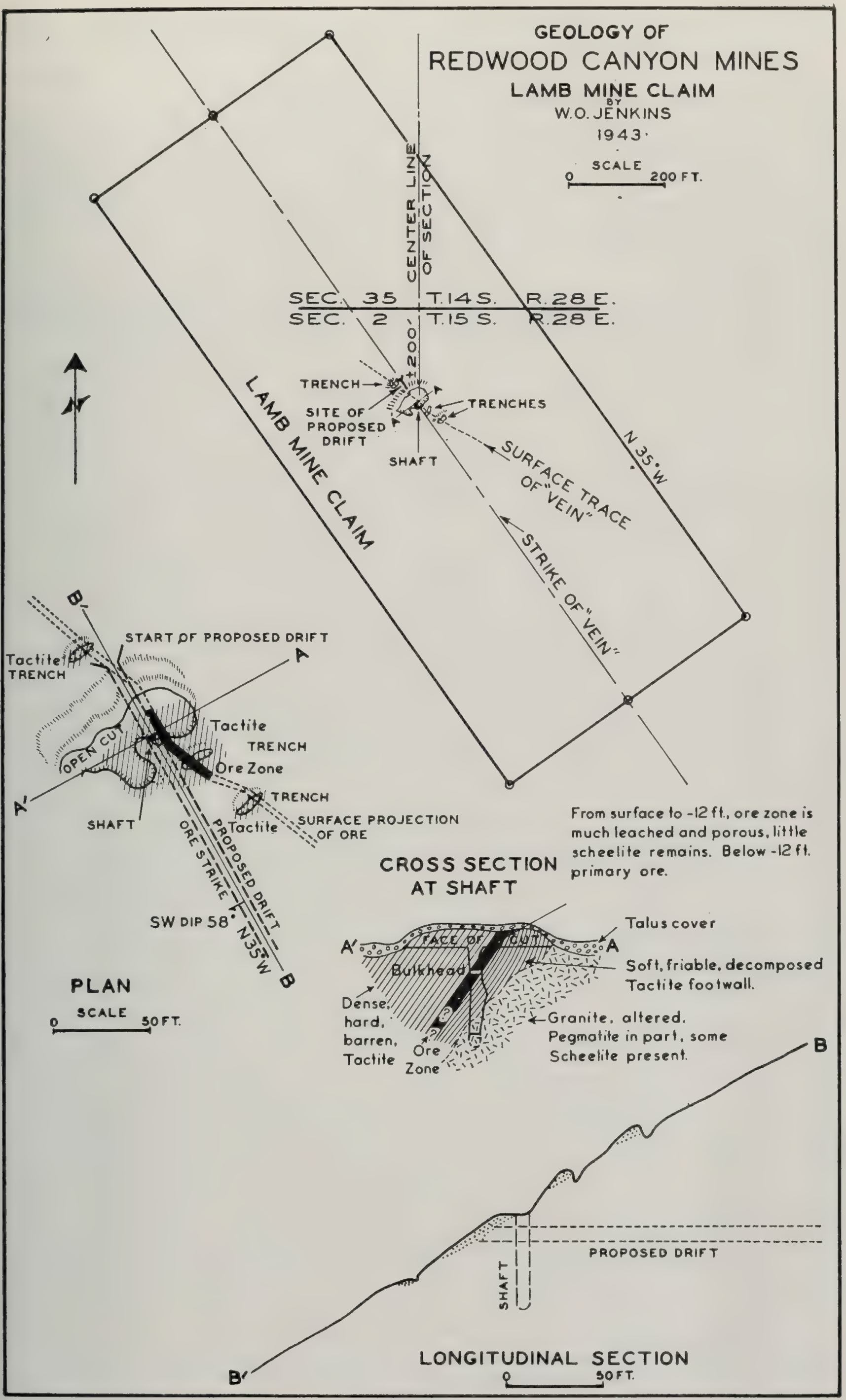
GEOLOGY OF
REDWOOD CANYON MINES
LAMB MINE CLAIM
BY
W.O. JENKINS
1943
SCALE
0
200 FT.
CENTER LINE OF SECTION
SEC. 35 T.14 S. R.28 E.
SEC. 2 T.15 S. R.28 E.
+200'
LAMB MINE CLAIM
TRENCH
SITE OF PROPOSED DRIFT
TRENCHES
SHAFT
SURFACE TRACE OF "VEIN"
N 35° W
STRIKE OF "VEIN"
N
B'
START OF PROPOSED DRIFT
A
Tactite TRENCH
Tactite
TRENCH
OPEN CUT
Ore Zone
A'
TRENCH
SHAFT
Tactite
SURFACE PROJECTION OF ORE
ORE STRIKE
PROPOSED DRIFT
SW DIP 58°
N35°W
B
PLAN
SCALE
0
50 FT.
From surface to -12 ft., ore zone is much leached and porous, little scheelite remains. Below -12 ft. primary ore.
CROSS SECTION AT SHAFT
Talus cover
A'
FACE OF CUT
A
Bulkhead
Soft, friable, decomposed Tactite footwall.
Dense, hard, barren, Tactite
Ore Zone
Granite, altered. Pegmatite in part, some Scheelite present.
B
PROPOSED DRIFT
SHAFT
B'
LONGITUDINAL SECTION
0
50 FT.

FIG. 3. Geology of Redwood Canyon Mines, Lamb Mine claim.

from it. It is in turn in contact with granite, which is exposed in the bottom part of the shaft. In the shaft, the footwall zone between granite and ore is about 12 feet thick; at the surface the distance is in excess of 15 feet, but lack of exposures prohibits its determination.

A small amount of scheelite may be found in the footwall tactite where it is exposed in the shaft, and some is even present in the granite at the shaft bottom. This granite is in part pegmatitic and is thought to be a differentiate of the main mass and probably closely related to the deposition of scheelite in the adjacent rocks.

Other Deposits

There are two or three occurrences of tungsten ore 3 or 4 miles south of Lemon Cove, upon which a little exploration work has been done.

GEOLOGY OF THE SAN BENITO QUADRANGLE, CALIFORNIA*

By Ivan F. Wilson

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* Thesis prepared in partial fulfillment of requirements for Ph.D degree, Department of Geological Sciences, University of California, Berkeley. Manuscript submitted for publication March 1943.

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ABSTRACT

The San Benito quadrangle, located 125 miles southeast of San Francisco, embraces parts of the Gabilan and Diablo Ranges of the central Coast Ranges of California. It includes a part of the Pinnacles National Monument, which lies mainly to the south; and is traversed by the San Andreas fault zone. The quadrangle is mapped on a scale of 1:62,500.

Topographically most of the region is in a stage of late youth or early maturity, but remnants of an older cycle of erosion which reached late maturity are preserved both in the Gabilan and Diablo Ranges. The steep southwestern front of the Diablo Range is characterized by large landslides. Five types of vegetation are distinguished, which show a decided geological influence in their distribution.

Some 36 cartographic units were mapped. These occur in three main stratigraphic provinces: (1) the Butts Ranch syncline, in the eastern part of the area; (2) the San Benito River area, a northwest-trending belt in the central part of the quadrangle; and (3) the Gabilan Range, to the southwest. In the first two provinces, located in the Diablo Range, Franciscan (Upper Jurassic) is the oldest rock exposed; in the Gabilan Range, Santa Lucia granite (pre-Franciscan) is the basement rock.

In the Diablo Range, Franciscan is overlain by undifferentiated Knoxville and Paskenta shales (Upper Jurassic and Lower Cretaceous); a considerable thickness of marine sandstone and shale in the Upper Cretaceous Panoche group, divided into four members; and a thin belt of the Upper Cretaceous Moreno shale. Four middle and upper Eocene formations are distinguished in the Butts Ranch syncline, and two middle Eocene formations are found in the Browns Valley area in the northwestern part of the quadrangle. The youngest beds in the Butts Ranch syncline belong to the middle Miocene Temblor group, divided into three members. These Eocene and middle Miocene formations are chiefly alternating marine sandstones and foraminiferal shales.

Miocene volcanics overlie the Santa Lucia granite in the Gabilan Range, and are particularly well developed in the Pinnacles National Monument and in the Willow Creek area. These consist of rhyolite flows and dikes, a few basic flows, and a great thickness of subaerial rhyolitic breccias, known as the Pinnacles formation, believed to have been formed by vulcanian eruptions. The volcanics are overlain by the upper Miocene Monterey group, divided into three members. The Monterey sediments record a fluctuating Miocene shoreline on the eastern edge of the Gabilan Range, in that marine diatomaceous shale interfingers with and grades into non-marine arkosic sandstone and conglomerate toward the west. The coarseness of the interbedded conglomerate indicates that conditions of clear, quiet water, usually postulated for the deposition of diatomaceous shale, were not present.

In the San Benito River area Franciscan is overlain by fossiliferous littoral deposits of the upper Miocene Santa Margarita formation and the Pliocene Etchegoin group. Fossils indicate the presence of all three Pliocene divisions of the Coalinga district—Jacalitos, Etchegoin (restricted), and San Joaquin; but these could not be separated lithologically. A series of red beds was distinguished at the base of the Etchegoin group.

Much of the area was blanketed by Plio-Pleistocene land-laid sediments—the San Benito gravels—deposited later than, and probably as a result of, the main period of deformation of the region (upper Pliocene).

Two separate Tertiary seaways connecting the San Joaquin Valley with the Coast are believed to have crossed the Diablo Range. The earlier seaway, during the Eocene and middle Miocene, ran eastward through the Butts Ranch syncline and Vallecitos to the San Joaquin Valley. The upper Miocene and Pliocene seaway was farther southwest, and ran southeastward along the San Benito River and Waltham Canyon to the Valley. The shift of position is thought to have been caused by pre-Pliocene folding of the Butts Ranch syncline.

The structure well illustrates the contrasting effects of deformation on a ''thin-blanketed'' area—the Gabilan Range—consisting of a granite basement with a comparatively thin sedimentary cover; and a ''thick-blanketed'' area—the Diablo Range—containing over 10,000 feet of foldable Franciscan sediments and an equal thickness of younger sediments. The rocks in the Gabilan Range have been deformed chiefly by faulting, and by gentle folding of the sediments; whereas those in the Diablo Range have undergone strong folding, overturning, and thrust-faulting. Several high-angle thrust faults are in the area; the most important of these is the San Benito fault, developed from a broken anticline, along which a belt of Etchegoin sediments half a mile wide has been overturned for a length of 12 miles. Several of the thrust faults show evidence of reversal of movement after deposition of the San Benito gravels (Plio-Pleistocene). The Bear Valley fault, which separates the granite and Franciscan basements, shows evidence of three periods of activity, starting probably in the Eocene, including two reversals of movement. The major structural features other than the thrust faults are the Butts Ranch syncline, a broad steeply folded and faulted structure, and the Tres Pinos syncline, a wide synclinorium in the main Franciscan area in the northern part of the quadrangle.

The only active faults in the area are the San Andreas, and a parallel fault, the Paicines fault. Both show evidence of recent horizontal displacement, the southwest side of each having moved relatively northwest. The San Andreas fault, which appears to be of comparatively recent origin, in part developed along the line of weakness of the granite-Franciscan contact followed by the Bear Valley fault, but it developed a straighter course. The steeply dipping Bear Valley fault diverges as much as half a mile southwest of the San Andreas.

The structural history indicates not just one period of folding, often attributed to the Pleistocene in other parts of the Coast Ranges, but rather a series of deformations dating back at least to the Eocene, the strongest being that of the upper Pliocene. The deformations recognized are: (1) normal faulting along the Bear Valley fault, uplifting the ancestral Gabilan Range, probably in the Eocene; (2) gentle folding of part of the Butts Ranch syncline area in the middle Eocene; (3) normal faulting in the Gabilan Range in the middle Miocene; (4) folding of the Butts Ranch syncline, probably between middle and upper Miocene, at least between middle Miocene and middle Pliocene; (5) the most important deformation—strong folding, overturning, and thrust-faulting in the upper Pliocene; (6) gentle folding and faulting, including reversals of movement along upper Pliocene thrust faults, in the late Pleistocene or Recent; and (7) recent horizontal displacement along the San Andreas and Paicines faults—the only deformation which is considered to be ''active.''

Economic deposits have not been greatly developed in the area. The principal deposits are quicksilver, occurring along faults mainly in Franciscan silica-carbonate rock and serpentine; and manganese ore, deposited as sedimentary lenses in Franciscan chert. A small amount of bentonite has been mined from Miocene vent tuff and a tuffaceous layer in the Pinnacles formation. Prospecting has been carried on for chromite, in Franciscan serpentine; gold, said to be an original constituent of Miocene rhyolite; copper, occurring in mineralized zones in granite and in Franciscan sandstone; and coal, occurring as a thin impure, lignitic layer in the San Benito gravels. The oil-bearing formations of the Coalinga and Kettleman Hills districts cross the quadrangle, but favorable structures for the accumulation of petroleum do not appear to be present.

INTRODUCTION

Despite the wealth of information regarding the California Coast Ranges that has accumulated under impetus of the search for oil, there are still many complicated areas in the highly folded heart of these ranges which have scarcely been touched by the geologist. In recent years, detailed studies of some of these regions—notably the Santa Lucia Range—by Taliaferro and his students, have revealed that many of our concepts of Coast Range structure and structural history, derived largely from a study of the oil districts, must be revised. In particular they suggest that the Coast Ranges have not undergone just the one period of folding often attributed to the Pleistocene, but have been subjected to a series of deformations of greater or lesser importance dating back at least as far as the Cretaceous. Because these deformations died out toward the basins and margins of the ranges, which are the most-studied portions, they have often been overlooked.

The San Benito quadrangle, covering parts of the Gabilan and Diablo Ranges, is fortunately situated for a study of Coast Range structural history and stratigraphy. Located midway between Monterey Bay and the Coalinga-Kettleman Hills oil districts, it was crossed by two separate seaways which connected the San Joaquin Valley with the coast during the Eocene, Miocene, and Pliocene periods. Owing to pre-Pliocene folding, the Pliocene seaway had a different course from that of the earlier epochs. The stratigraphic succession in the quadrangle is nearly as complete as in any other part of the Coast Ranges, and the stratigraphic and faunal details fill a gap between the better-known areas along the Coast and the San Joaquin Valley.

The structural complexity of the area is rendered interesting by not one, but several periods of deformation. Of at least three epochs of folding represented, the latest (Pleistocene) was the least severe—contrary to the condition found along the edge of the San Joaquin Valley. Also of considerable interest is the discovery of reversals of movement along some of the faults—including a close neighbor of the well-known San Andreas fault, which traverses part of the area. The San Andreas fault itself—one of the two ''active'' faults in the region—appears to be of relatively recent origin.

The writer spent about 8 months in field mapping, during the summers of 1938, 1939, and 1940, and at other intervals during these years. The quadrangle is mapped by the U. S. Geological Survey on a scale of 1:62,500, and covers 246 square miles. Aerial photographs made for the Agricultural Adjustment Administration became available in the fall of 1939, and proved very useful in working out certain features of the geology.

Several local geographic names have been added to the topographic map and a few others changed in accordance with local usage to facilitate discussion of the geological features. The misspelling of ''Butts

Ranch'' on the map is pointed out, as this is an important place name used in describing certain of the formations.

Fossil localities have been eliminated from the text to conserve space, but a list of localities may be consulted in the copies of the unpublished thesis obtainable at the University of California Library at Berkeley.

ACKNOWLEDGMENTS

The writer is indebted to Dr. N. L. Taliaferro, who suggested the problem, accompanied the writer in the field, and made valuable suggestions and criticisms. Dr. H. G. Schenck gave repeated encouragement and assistance, spent several days with the writer in the field, and made many of the foraminiferal collections and paleontologic determinations. Dr. B. L. Clark was very helpful in determining numerous fossils. Dr. Howel Williams accompanied the writer in the field and contributed valuable suggestions. All of the provisional foraminiferal identifications are by Miss Lois T. Martin. Various paleontologic determinations were made by Dr. F. M. Anderson, Dr. Ralph W. Chaney, Dr. Leo G. Hertlein, Dr. A. Myra Keen, Mr. Louis Simon, and Dr. R. A. Stirton.

Dr. R. C. Mielenz and Mr. N. R. Park were companions in the field during the first summer, and participated in helpful discussions on adjoining areas. Mr. Max B. Payne visited the writer in the field and made constructive suggestions. The writer wishes to express his gratitude to the ranchers of the area, particularly Mr. and Mrs. William Butts, for their kind hospitality and assistance.

The writer is grateful to Dr. Geo. D. Louderback of the Board of Editors of the University of California Publications in Geological Sciences for releasing the manuscript so that it might be published at an earlier date, and to other members of the Board of Editors, Dr. Chas. A. Anderson, Dr. Ralph W. Chaney, and Dr. Howel Williams, for reading the manuscript.

LOCATION AND GEOGRAPHIC FEATURES

The San Benito quadrangle is located in the central part of San Benito County, about 125 miles southeast of San Francisco. It includes parts of the Diablo and Gabilan Ranges of the central Coast Ranges of California. The quadrangle contains no towns or settlements, but only scattered ranches. Hollister, the San Benito County seat, lies 25 miles to the northwest. The former settlement known as San Benito contains only a post office and a few abandoned stores. The land is used chiefly for cattle-grazing, although hay and grain (barley, oats, and wheat) are cultivated in small areas.

The Pinnacles National Monument lies to the south, extending a short distance into the southwestern part of the quadrangle.

The San Benito quadrangle is readily accessible by roads running parallel with its two main northwest-trending valleys, the San Benito River and Tres Pinos Creek. State Highway 25, a good paved road, runs through the area from Hollister in the northwest to Bitterwater in the southeast. This is part of the ''Airline Route'' from San Francisco to Los Angeles, via Hollister, Priest Valley, Coalinga, and Taft.

The other main road is the ''Panoche Pass road,'' State Highway 180, which extends from Paicines along Tres Pinos Creek, across

Panoche Pass, into Panoche Valley. In former years stagecoaches traveled this route from the New Idria mines to San Juan Bautista. Bandits are said to have frequented the route, among them the notorious Tiburcio Vasquez. Highway 180 is for the most part an improved dirt road, but the section extending through the Franciscan on Tres Pinos Creek has long been known as the "Wiggletail," because of its narrow, winding, steep grades.

Climate

The climate of the San Benito region is semiarid. It is transitional between that of the more humid Santa Lucia Range lying along the Pacific Coast to the west, and the arid Panoche Valley and western border of the San Joaquin Valley to the east. Precipitation is almost entirely in the form of rain, and is confined largely to the winter and spring months. The average annual rainfall at Hollister is 13 inches; the mean for San Benito County is estimated to be 16 inches (Anonymous 38, p. 20). The temperature falls below freezing for short periods during the winter months, and reaches 80° to 100° F. in summer.

Vegetation

The natural vegetation of the San Benito quadrangle may be divided into various types which show decidedly the influence of geological as well as nongeological factors in their distribution. In some places a formation may almost be mapped by its distinctive type of vegetation. However, in other places formational contacts show no influence upon the vegetation, and vegetation contacts may occur where there is no apparent change in geological conditions. Permeability seems to be the most important geological controlling factor. The sharpest vegetative changes not related to geology are produced by the differences between relatively southerly and northerly slopes; other nongeological factors are differences in elevation and relative steepness of slope.

In the course of geological mapping the writer noted five main classes of vegetation whose distribution was notably influenced by geological factors. These are:

(1) *Grassland* (annual grasses and herbs). Grassland alone, barren of trees, occurs chiefly on clays and clay-shales, such as the Knoxville and Paskenta formations, and on parts of the San Benito gravels, terraces, landslides, and alluvium.

(2) *Savanna.* This type includes various species of live oaks, scattered among annual grasses and herbs, and also some conifers at the higher elevations. It is the most widespread vegetative type and may occur in various geological environments, including:

(a) Southerly slopes of clays and shales, such as those of the Panoche group, Lodo formation, Kreyenhagen shale, Temblor shale, Monterey group.

(b) Northerly slopes of sandstones, such as the Panoche, Temblor, Santa Margarita, and Etchegoin.

(c) Formations producing a relatively thick soil cover, such as the Franciscan; and moderately unconsolidated deposits, such as the basal red beds of the Etchegoin, and the San Benito gravels.

(3) *Sagebrush and related low brush.* This occurs chiefly on sandstones, such as the Tres Pinos, Monterey, Santa Margarita, and Etchegoin. It also occurs on the sandy soil formed by granite. This type of brush is less dense than the two succeeding types.

(4) *Chaparral.*

(a) *Scrub oak and related brush.* Dense growths of scrub oaks, wild cherry, and related brush are most characteristic of the northerly slopes of shales, such as the Lodo, Kreyenhagen, and Temblor.

(b) *Chamise and manzanita.* Chamise and scattered manzanita form the densest brush cover in the region, parts of which are nearly impenetrable. They occur chiefly on the southerly slopes of sandstones, such as the Panoche, Temblor, and part of the Etchegoin; and also the sandy soil derived from granite.

PREVIOUS LITERATURE

The first mention of any part of the San Benito region was made by the English sea-captain, George Vancouver, on an exploring trip to the Pacific Coast in 1794. While waiting for his ships to be repaired at Monterey, he journeyed up the Salinas Valley as far as the Pinnacles where he ''was there gratified with the sight of the most extraordinary mountain'' he had ever beheld (Vancouver 94, p. 334). His journal includes a sketch of the Pinnacles made by one of his party.

Whitney and Brewer traversed the San Benito quadrangle while en route to the New Idria quicksilver mine in 1861, and both noted the unusual thickness of gravels (San Benito gravels) exposed along Tres Pinos Creek (Whitney 65, pp. 52-53; Brewer 30, pp. 135-138). Lawson further noted these gravels in 1893 (Lawson 93b, pp. 151-153).

Some of the reports of the California State Mining Bureau covering parts of the San Benito quadrangle include those by Irelan (88, pp. 483-490; 93, pp. 370-373), Fairbanks (94), Forstner (03, pp. 125-149), Bradley (18, pp. 101-102), Bradley and Logan (19), Vander Leck (21, pp. 69-70), Boalich (22), and Laizure (26). Fairbanks' paper includes three cross-sections of parts of the San Benito quadrangle.

Robin Willis made a physiographic study of part of the San Andreas fault in 1924, which includes a generalized geologic map of part of the San Benito quadrangle (Willis 24; 25). The most important previous geologic investigation is that of Kerr and Schenck (25). Their published map on a scale of 4 miles to 1 inch covers approximately the northwest one-third of the San Benito quadrangle.

The Pinnacles National Monument was studied by Andrews (36). His published map chiefly covers the adjoining Metz quadrangle to the south, but overlaps northward about 1 mile into the southern part of the San Benito quadrangle. Parts of the Priest Valley and Panoche quadrangles adjoining the San Benito quadrangle on the southeast and east were mapped by Mielenz (39). Other nearby areas to the southeast have been mapped by Pack and English (14) and to the east by Vokes (39).

GEOMORPHOLOGY

The California Coast Ranges are a series of ranges trending northwestward, parallel with the general structural trends of their underlying rocks. The individual ranges trend more nearly westward than the belt of ranges as a whole, so that they are successively truncated on the west by the Pacific Ocean. In the latitude of San Benito County the Coast Ranges have the following major divisions, starting from the coast at the west: the Santa Lucia Range, the Salinas Valley, the Gabilan Range, the Hollister Basin or San Benito Valley, and the Diablo Range. Parts of the Gabilan and Diablo Ranges comprise the San Benito quadrangle. Their dividing line is distinct in the vicinity of Hollister, where they are separated by a broad valley, but becomes less distinct to the southeast. The geologic boundary between the characteristic rock complexes of the two ranges is formed by the Bear Valley fault and in part by the San Andreas fault zone.

The San Benito quadrangle has several drainage systems. The most important is the San Benito River system which flows northwest into the Pajaro River near Hollister, and thence into Monterey Bay. Tres Pinos Creek, which drains nearly all of the northern half of the quadrangle, forms a subsidiary system, but joins the San Benito River southeast of Hollister. The southwestern part of the quadrangle is drained by Chalone Creek, which flows southward, then southwestward across the Gabilan Range, and empties into the Salinas River near Metz. The Salinas River flows northward into Monterey Bay. A small part of the eastern edge of the quadrangle, from Panoche Pass south to Bitterwater Creek, is drained to the east into the Panoche Valley and San Joaquin Valley.

The drainage pattern is in general irregular, varying from subdendritic to subtrellis, depending upon the underlying rock. The San Benito River in general has a subsequent course, parallel to the northwest-trending structures of the region, except for two step-like breaks (at San Benito, and at Sulphur Creek), in each of which it is shifted about 2 miles to the west. Tres Pinos Creek is roughly subsequent, paralleling strikes in the Franciscan and the San Benito gravels, except for the stretch between Las Aguilas Creek and Emmett School, where it cuts across the strike and is entrenched in a narrow, steep canyon. This part of its course is thought to have been superimposed from a cover of San Benito gravels. Bear Valley also has a rudely subsequent course. The upper part of its drainage has been captured by a stream running northwest into Willow Creek. Most of the other streams in the area are consequent, although a few, such as Paynes Creek, may be superimposed.

Cycles of Erosion

The San Benito quadrangle shows evidence of at least two cycles of erosion. The first cycle reached a stage of late maturity, represented by broad alluviated valleys and well-rounded ridges preserved in the higher elevations of both the Gabilan and Diablo Ranges. These valleys have been entrenched and destroyed over large areas by actively downcutting streams in V-shaped canyons representing the second or present cycle, which is still in a stage of youth, or, in part, of early maturity. The second cycle may, in places, be divided into two substages.

Gabilan Range

A number of broad, late mature valleys representing the first cycle of erosion are situated near the crest of the Gabilan Range, at an elevation of 2,000 to 2,500 feet. Most of these lie west of the San Benito quadrangle in the Gonzales quadrangle. Most notable are Gloria Valley, Williamson Valley, and the heads of Willow Creek and the South Fork of Willow Creek. In the San Benito quadrangle, Chalone Creek and Bickmore Canyon, draining toward the east, descend rather abruptly into steep, narrow, V-shaped youthful canyons which contrast strongly with the broad valleys at their heads. Obviously the broad valleys at the crest of the range could not have been formed by the present erosion cycle but are instead being destroyed by it. Both cycles are developed in granite, so that the factor of differential erosion may for the most part be eliminated.

Longitudinal stream profiles (fig. 2) constructed along Chalone Creek, Bickmore Canyon, and the two forks of Willow Creek clearly show the boundaries separating the two cycles by definite ''knickpoints'' (Knopf 24, p. 636). Subsidiary knickpoints along some of these canyons indicate two substages of the second cycle. It should be understood that knickpoints may also be caused by differences in resistance of rocks, as illustrated on the profile of Paynes Creek. However, in the cases mentioned above the rock is the same on either side of the knickpoints.

Diablo Range

Remnants of the first cycle of erosion in the Diablo Range are preserved chiefly in the northern third of the quadrangle. These comprise a number of broad alluviated valleys, including Browns Valley, Los Muertos Valley, Coyote Valley, Dairy Flat, Las Aguilas Valley, Slacks Valley, Lankford Flat, three unnamed valleys north of Las Aguilas Creek, and a broad flat area south of Sugarloaf. Some of these valleys contain poorly drained, swampy areas. They are being entrenched and drained in their lower portions by youthful V-shaped canyons. Both cycles here are developed in sandstones and shales of the Franciscan group; differential resistance to erosion was not instrumental in determining the position of the broad valleys.

Longitudinal stream profiles of Las Aguilas Creek and Los Muertos Creek show definite knickpoints at boundaries between the two cycles. Tributaries to these streams possess ''hanging valleys'' where they pass from the first cycle of the tributary valleys to the second cycle.

In the Diablo Range south of Tres Pinos Creek the first cycle can not be distinguished with certainty. This part of the area is in a general stage of late youth or early maturity. A surface of low relief, tilted toward the northwest, is preserved on the Call Mountains. Although this surface might be correlated with the first-cycle valleys of Las Aguilas region, it seems more likely that it may be a surface formed below the San Benito gravels and preserved when the gravels were stripped off. The inclination of the gravels immediately to the west is essentially parallel with the tilt of this surface.

Big Oak Flat at the head of Paynes Creek is evidently a remnant of an earlier cycle of erosion, which may or may not be a correlative of the first cycle of Las Aguilas region. It is an alluviated valley entrenched on the northwest by Paynes Creek. Its southeastern part has been steeply entrenched and captured by Horsethief Canyon, which has a much steeper gradient.

STRATIGRAPHY

Stratigraphic Provinces

The San Benito quadrangle may be divided into three stratigraphic provinces, based upon the present distribution of the formations. The Gabilan Range to the southwest has a granite basement overlain by Miocene sediments and volcanics. The Diablo Range to the northeast has a Franciscan (Upper Jurassic) basement, overlain by two different sequences of younger formations. In the eastern part of the area is the Butts Ranch syncline, with a great thickness of Cretaceous, middle and upper Eocene, and middle Miocene sediments. Between the Butts Ranch syncline and the Gabilan Range is the San Benito River area, in which the Franciscan is overlain by upper Miocene and Pliocene sediments. Related to the Butts Ranch syncline and not considered a separate province is the Browns Valley area in the northwest part of the quadrangle which contains, in addition to Franciscan and Cretaceous, two middle Eocene formations. Plio-Pleistocene nonmarine sediments overlap various parts of the entire region.

Stratigraphic columns are presented for each of the three main stratigraphic provinces—the Gabilan Range, San Benito River area, and Butts Ranch syncline (figs. 3, 4, 5). Formations from the different areas are described together in the succeeding pages in order of decreasing age.

Gabilan Limestone (Pre-Santa Lucia Granite)

The oldest formation in the region is the Gabilan limestone (Becker 88, p. 181), considered a member of the Sur series (Trask 26, p. 134). This occurs as isolated roof pendants in the Santa Lucia granite, and also as a fault breccia along the San Andreas fault zone. Only one roof pendant, less than 100 feet wide, was found in the San Benito quadrangle, in the Chalone Creek region; but several outcrops occur to the south in the Metz quadrangle (Andrews 36, p. 7). Fairly large areas of the limestone are exposed near Fremont's Peak to the northwest in the San Juan Bautista quadrangle.

The rock is a white to bluish-gray, thoroughly recrystallized marble, often exhibiting a faint banding. The largest mass of fault breccia, 1½ miles long and 500 feet wide, occurs southwest of the San Benito River between the Jungle Inn and Willow Creek School. Two smaller exposures occur farther southeast along the San Andreas fault zone. The fault breccia consists of angular fragments of crystalline limestone, 3 or 4 inches to 50 or more feet in diameter, firmly cemented into a resistant mass which forms prominent outcrops. Where exposed over a fairly large area, it supports a dense growth of chaparral (chamise and manzanita).

The Gabilan limestone is older than the Santa Lucia granite; otherwise its age is conjectural. From comparisons with Sierran formations and geologic history, Taliaferro (41, p. 123) concludes that all the available evidence concerning the Coast Range basement-complex rocks (of which the Gabilan limestone is a part) points to their being older than Upper Paleozoic: "They may be Lower Paleozoic or pre-Cambrian or both."

Santa Lucia Granite (Pre-Franciscan)

Intrusive into the Gabilan limestone is the Santa Lucia granite (Lawson 93a, p. 6). This is chiefly biotite granite, with some more basic phases, extensively intruded by aplite and pegmatite dikes. The granite comprises most of the northern part of the Gabilan Range, and is exposed over an area of 15 square miles in the southwestern part of the San Benito quadrangle. Two isolated outcrops occur as fault slivers along the San Andreas fault zone. The granite is highly jointed, usually deeply weathered and poorly exposed. It weathers to a reddish-brown arkosic soil, and forms rounded slopes. It supports a growth of dense brush, either chamise or sagebrush type, which is thickest on southerly slopes.

The most common type of rock is a coarse-grained biotite granite (average grain size 2 to 5 mm), containing large flesh-pink orthoclase crystals. Microscopically the feldspars are seen to be chiefly orthoclase, in part microperthite, and subordinate microcline. Myrmekitic intergrowths of vermicular quartz and untwinned feldspar are common. Plagioclase is subordinate, varying from basic albite to oligoclase ($Ab_{90}An_{10}$ to $Ab_{80}An_{20}$). It exhibits both albite and Carlsbad twinning. The feldspars show partial alteration to kaolin and sericite. Quartz, making up 25 to 40 percent of the rock, is highly granulated, showing mosaic structure and undulatory extinction. Biotite usually comprises 10 percent or less of the rock. Both brown and green varieties are present. The former is pleochroic with X, light yellow, Y and Z, deep golden brown; the latter shows X, greenish yellow, Y and Z, dark green. The biotite has been partially altered to chlorite. The minor accessories are magnetite, zircon, and apatite. More basic rocks, carrying more plagioclase, less quartz, and hornblende as well as biotite, approach quartz monzonite or granodiorite in composition.

Numerous aplite and pegmatite dikes intrude the granite. They range in width from a few inches to several feet. The pegmatites are composed chiefly of flesh-pink orthoclase (in part microperthite) and quartz, sometimes in the form of graphic intergrowths. Plagioclase (albite to oligoclase) is rare. Muscovite is the only important accessory, and some magnetite is present. Some of the pegmatites are granulated and crossed by microscopic veinlets and stringers of calcite. The aplite consists of fine-grained flesh-pink orthoclase and quartz, and subordinate plagioclase.

Most contacts with the Santa Lucia granite in this area are faults. In the Willow Creek area, however, the basal shale of the Monterey, and elsewhere the Miocene rhyolite, rest directly on the granite. The granite is extensively intruded by rhyolite dikes in the extreme southwestern part of the quadrangle.

Beyond the fact that it is pre-Franciscan, the age of the Santa Lucia granite is unknown. All known contacts between the granite and the Franciscan are faults; but various lines of evidence that the granite is older than the Franciscan were pointed out by Lawson (14,

p. 7). Taliaferro (41, p. 123) considers that the granite is probably older than Upper Paleozoic.

Franciscan Group (Upper Jurassic)

The Franciscan group (Lawson 95, p. 347) is a heterogeneous series of arkosic sandstones, shales, occasional conglomerates, radiolarian cherts, and pillow basalts or ''greenstones.'' It is intruded by ultra-basic rocks, altered to serpentine, which have locally produced contact aureoles of glaucophane and actinolite schists. The cherts and basalts are less abundant than in some other areas, and probably more than 90 percent of the group here consists of unmetamorphosed interbedded sandstones and shales. The only lithologic type reported elsewhere but missing here is limestone. The Franciscan rocks vary in their resistance to erosion and form a characteristic ''knobby'' topography. They support a growth of oaks and grasses, and chaparral on some of the schist areas.

Franciscan rocks cover the entire northeastern quarter of the San Benito quadrangle. This is only part of a large Franciscan area which extends to the north and forms most of the central portion of the Diablo Range. Discontinuous narrow strips of Franciscan have been brought to the surface farther southwest in the quadrangle, along thrust-faults, such as the San Benito, Pine Rock, and Bear Valley faults. Occasional patches are also exposed along the San Andreas fault zone. Franciscan rocks probably form the basement for the entire area northeast of the Bear Valley fault.

The thickness of the Franciscan group is usually difficult to estimate because of strong folding and the lack of exposures of the base and top. However, a fairly regular section across the north limb of a syncline is exposed along Las Aguilas Creek. Here a minimum thickness of 10,000 feet was measured, and neither the base nor top was exposed.

Sandstone is the most abundant rock in the Franciscan group. It is bluish gray or bluish green when fresh, weathering to greenish brown or yellowish brown. The structure varies from massive to well bedded and platy. Poor sorting and great angularity of grain are noticeable features. The constituents are quartz and feldspars, about equally divided; rock fragments, chiefly black shale; and various minor accessories, including biotite, muscovite, magnetite, zircon, sphene, and epidote. The grains are separated by finely divided chloritic and sericitic material. The feldspars are chiefly plagioclase (andesine and oligoclase), subordinate orthoclase and occasional microcline. The sandstone is commonly traversed by small calcite and quartz veinlets, especially in the vicinity of ultra-basic intrusives. Adjacent to some of the intrusives, the sandstone becomes increasingly friable and is bleached to light shades of pink and purple, or almost to white. These changes are attributed to hydrothermal alteration.

Interbedded with the sandstones are thin, hard, platy clay-shales, black or bluish-gray in color, which grade into sandy shale and shaly sandstone. Carbonaceous material and unidentifiable plant remains are often present.

Franciscan conglomerates are rare in this area. They most commonly contain fine pebbles, $\frac{1}{4}$-inch or less in diameter, composed of black shale and chert fragments evidently derived from the Franciscan itself. A lens of coarse conglomerate 30 feet thick occurs 1 mile northeast of the mouth of Antelope Creek. It contains in a sandstone matrix subrounded to well-rounded pebbles averaging 2 to 3 inches and ranging up to 18 inches in diameter. The pebbles are chiefly porphyries (including feldspar, quartz-feldspar, and quartz porphyries), black cherts, and black fine-grained quartzites. Similar pebbles are found in nearly all succeeding conglomerates in this region, from Cretaceous to Pleistocene, but the rocks from which they were derived are nowhere exposed in the Coast Ranges. Probably many of the pebbles were reworked from one conglomerate to the next. In this report they are referred to as the ''pre-Franciscan'' type of pebble. Other constituents of the Franciscan conglomerate lens are a few sandstone pebbles of Franciscan origin, which are less rounded than the pre-Franciscan pebbles.

Lenses of radiolarian chert are interbedded with the other Franciscan sediments. They may be massive or well bedded, with thin partings of clay-shale; they are commonly contorted and crumpled. The color of the well-bedded types is generally red or green, of the massive varieties more commonly white or gray. Black manganese oxide stains occur along some of the bedding-planes and joints. The chert lenses thicken and thin abruptly, ranging from a few feet to several hundred feet in thickness. None could be traced for more than half a mile along the strike. The cherts represent chemical precipitates of silica, most likely contributed to the water by submarine volcanism (Taliaferro 33). The petrography of the chert has been described by Davis (18b).

Small lenticular outcrops of pillow basalt or ''greenstone'' occur in the Franciscan, often closely associated with the chert lenses. The rock is generally massive, greenish in color, and highly altered. Ellipsoidal pillows 2 to 3 feet in diameter are present locally. Although most of the basalts are roughly concordant with the adjacent sediments, some show slightly cross-cutting intrusive relationships; others may represent submarine flows. Veinlets and amygdules of quartz and calcite are common. Saussuritized feldspar and occasional augite phenocrysts are the only constituents ordinarily recognizable with a lens. A microscopic study of one sample revealed phenocrysts of augite in an intersertal groundmass composed of lath-shaped feldspars and smaller equidimensional augite crystals separated by a matrix of dark-gray, devitrified glass. Magnetite is common in the groundmass and in veinlets. Veinlets and patches of green chloritic material occur in addition to quartz veinlets.

Masses of serpentine intrude the other rocks of the Franciscan group. They are products of hydrothermal alteration of ultra-basic rocks such as peridotite and dunite. They are colored green or bluish green. One common variety is massive, and has numerous slickensided and polished surfaces; another is coarsely crystalline, containing bastite pseudomorphs of orthorhombic pyroxenes. Narrow belts of serpentine have been squeezed up along some of the faults, such as the

Pine Rock and San Benito faults, in the form of "cold intrusions." The largest masses of serpentine occur in the Tres Pinos Creek area north of the Bradford mine, where they are surrounded by aureoles of glaucophane and related schists. Serpentine is rare in the rest of the main Franciscan belt. The observed intrusive serpentines are obviously younger than the Franciscan sediments, but evidence of more than one period of intrusion is furnished by the presence of serpentine as a detrital mineral in the Franciscan sandstone, and the presence of both serpentine and glaucophane schist pebbles in Franciscan conglomerates (Davis 18a, pp. 20, 25).

An alteration product of serpentine known as silica-carbonate rock occurs along some of the faults in the San Benito quadrangle. It is a resistant rock, reddish to brownish in color, consisting of a mixture of chalcedony, quartz, and various carbonates in a myriad of interpenetrating veinlets. Similar rocks were attributed by Knopf (06) to hydrothermal alteration of serpentine.

A series of glaucophane, actinolite, and related schists has been developed by pneumatolytic contact metamorphism of the Franciscan sediments and volcanics around serpentine intrusions. The largest mass, about 4 miles long by 1 mile wide, occurs north of the Bradford fault near Tres Pinos Creek. A variety of types is represented, the most common being glaucophane-quartz-albite, glaucophane-albite-sericite, actinolite, and actinolite-albite schists. Other minerals commonly present are chlorite, garnet, epidote, sphene, magnetite, and biotite. An interesting type is that derived from chert. This consists of a granoblastic aggregate of quartz, showing mosaic structure and strain effects, and scattered prismatic crystals of glaucophane. Other minerals present are chlorite, muscovite, garnet, in euhedral dodecahedral crystals, and sphene, in euhedral crystals. Introduction to the original chert of Na_2O, K_2O, Al_2O_3, and TiO_2 seems indicated.

Where these rocks are schistose, the schistosity is determined by the original bedding, not by directed pressure. Schistosity planes parallel the bedding planes of the unaltered sediments. The Tres Pinos syncline may be traced through a belt of glaucophane schists by the planes of schistosity.

The origin of the schists by pneumatolytic action accompanying the ultra-basic intrusions seems demonstrated by the proximity of the schists to these intrusive bodies, and by their gradation into unaltered sediments both along and across the strike. The distribution of the schists in detail is spotty, probably reflecting the presence or absence of favorable channels for pneumatolytic action. A glance at the geologic map will show the general relationship of the schist bodies to the serpentines, but the clearest-cut field relations are demonstrated by an isolated intrusive body along Las Aguilas Creek[1] which is too small to represent on the map. Here a thin serpentine sill intruded into sandstone and shale has produced a narrow zone of glaucophane schist on either side. Surrounding this zone in all directions are thousands of feet of unaltered sandstones and shales. The sandstone strikes N. 50° W., dips 70° SW., and the serpentine sill and schistosity in the schist zone have attitudes essentially parallel with this. The various zones noted here, from south to north, are:

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[1] SE¼ SW¼ sec. 28, T. 14 S., R. 8 E., M. D.

	Thickness (feet)
(a). Normal Franciscan sandstone. Fine-grained; grayish to greenish	--
(b). Shale zone, partially altered. Has a glossy appearance, bluish color, showing development of fine-grained glaucophane	7
(c). Serpentine sill. Green, highly crumpled appearance. Filled with calcite veins. Slickensided and sheared surfaces	58
(d). Glaucophane schist. Fine-grained, schistose (probably from shale) to coarse-grained, granulose (probably from sandstone). Deep blue color. Shows glaucophane, albite, garnet; abundant veinlets of calcite	18
(e). Glaucophane and actinolite schist, cut in two places by small lens-like bodies of serpentine	9
(f). Zone of slightly altered shale, similar to (b); glossy, bluish appearance; interbedded with practically unaltered greenish sandstone	14
(g). Normal Franciscan sandstone, cut by few veinlets of quartz	--

The Franciscan sediments are dominantly clastics deposited under shallow-water, marine conditions in a sinking geosyncline. The abundance, freshness, and angularity of feldspar grains in the sandstones indicate fairly rapid transportation from a land mass in which mechanical disintegration dominated. From a study of the coarsening of Franciscan sediments, Taliaferro (41, p. 124) concludes that this land mass lay to the west of the present Pacific coast line.

The only contact of the Franciscan with older rocks is with the Santa Lucia granite along the Bear Valley fault. The base of the Franciscan has nowhere been seen. Most of the contacts with younger rocks are fault contacts, except for many of those with the San Benito gravels which are depositional.

The age of the Franciscan is now definitely established as Upper Jurassic. The most important fossils yet found are two ichthyosaur rostra in worn chert cobbles, reported by Camp (41). They indicate either an Upper Jurassic or Lower Cretaceous age, but there is abundant physical evidence against the latter possibility. Taliaferro (42) has established independent physical evidence of an Upper Jurassic age, based upon relationships to the equivalents of the Sierran Jurassic formations in northern California and southwestern Oregon.

Knoxville and Paskenta Formations, Undifferentiated
(Upper Jurassic and Lower Cretaceous)

The Knoxville and Paskenta formations (White 85; Anderson 02, pp. 43-47) consist chiefly of dark clay-shales with gray limestone concretions, and occasional interbedded greenish-brown sandstones. The shales are black to greenish black, soft, usually well bedded in layers 2 to 3 inches thick. Carbonaceous material is common. The abundant limestone concretions are usually fairly round, and may reach a diameter of 3 to 4 feet. The interbedded sandstones are poorly sorted, rich in feldspar and biotite, and usually thin-bedded and platy. The formations as a whole are very soft and form low, well-rounded hills, with numerous small slumps and mud-flows. The main vegetation is grass and widely scattered oaks.

The Knoxville and Paskenta are exposed in a long, discontinuous, narrow belt along the San Benito fault zone. They occur chiefly on the northeast or upthrust side of the fault, but appear occasionally in a zone between two or more branching faults. The thickness appears to be at least 500 feet. The formations are lithologically identical and inseparable in the field. Their base is not exposed, but they are overlain depositionally by the Panoche group in the southeastern part of the area. Although there is no exact paleontologic control for this upper contact, the lithologic boundary more or less arbitrarily chosen has a marked expression in the topography and vegetation. The overlying Panoche sandstone and shale produces steeper, more rugged slopes, with more numerous outcrops, and tends to support sagebrush or other low brush as well as numerous oak trees.

Abundant, well-preserved Aucellas collected by the writer from a limestone concretion were referred by both F. M. Anderson and S. W. Muller to the *Aucella piochii* group, supposedly characteristic of the Knoxville formation, Upper Jurassic. However, N. L. Taliaferro[2] reports specimens of the *Aucella crassicollis* group, in addition to the *Aucella piochii* group, from approximately the same locality. H. G. Schenck[3] also reports the *Aucella crassicollis* group from the same vicinity. This group has been considered characteristic of the Paskenta formation, Lower Cretaceous. N. L. Taliaferro suggests that the *Aucella crassicollis* group may extend down into the Knoxville, contrary to the general opinion. If this be true, perhaps only the Knoxville is represented in this area; but if the traditional ideas regarding the ranges of these fossils are correct, Knoxville and Paskenta may be juxtaposed without an actual contact being visible. The section is poorly exposed and is in a highly faulted area; a contact between the two formations is difficult to find at best, because of their lithologic similarity.

Panoche Group (Upper Cretaceous)

The Panoche group (Anderson and Pack 15, p. 39) consists of 5000 to 9000 feet of brownish concretionary arkosic sandstones; interbedded dark clay shales, greenish sandstones, and limestones; and lesser thicknesses of platy purplish calcareous foraminiferal shales. All are of shallow marine origin. Megafossils are rare, but Foraminifera are rather abundant. Both indicate an Upper Cretaceous age.

The Panoche group is exposed on both limbs of the Butts Ranch syncline, for a distance of about 9 miles. The two belts thus formed continue to the southeast beyond the limits of the quadrangle, and are overlapped to the northwest by the San Benito gravels. The southwest belt has a thickness of 7000 to 9000 feet; the northeast belt 5000 to 6000 feet. A separate mass of Panoche beds, with an exposed thickness of more than 4000 feet, occurs in the northwest part of the quadrangle, in the Browns Valley region, where it is in fault contact with the Franciscan to the north and the Eocene Los Muertos Creek formation to the south.

The Panoche group is in contact with the Franciscan along the northeast flank of the Butts Ranch syncline. This contact is a fault as far east as Chemise Ridge, but east of that point it appears to be depositional. The contact dips to the south as gently as 35° in Paynes Creek, essentially parallel with the dip of both the underlying and overlying beds. No basal conglomerate containing Franciscan debris was found; the Panoche consists of interbedded shales and sandstones right at the base. The contact must necessarily be unconformable, since the Knoxville and Paskenta formations are not represented. The Panoche group rests upon the Knoxville and Paskenta formations along the southwest side of the Butts Ranch syncline, although the contact could not be located with certainty. It is presumably unconformable, since the intervening middle Cretaceous Horsetown formation is missing.

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[2] Personal communication, March 1941.
[3] Personal communication, February 1941.

The lithologic members of the Panoche group vary in their influence upon topography and vegetation. The shales, and interbedded sandstones and shales, offer little resistance to erosion and form low, well-rounded slopes. They support oaks and grass, or occasionally low brush of the sagebrush type. The massive sandstones, in contrast, are among the most resistant rocks of the area and form prominent ridges and cliffs. They underlie the high parts of the Call Mountains, Big Mountain, and Pine Ridge. They support a dense growth of chaparral (chamise and manzanita) particularly on southerly slopes.

The Panoche group may be separated into several broad lithologic members, some of which possess distinctive faunas. These units, however, are not constant in all of the three belts exposed in the quadrangle. On the northeast side of the Butts Ranch syncline three divisions were made:

	Thickness (feet)
3. *Butts Ranch shale member.* Foraminiferal calcareous purplish shale	100– 300
2. *Call sandstone member.* Massive brownish concretionary sandstone	2600–2900
1. *Paynes shale and sandstone member.* Interbedded dark-colored clay-shale, greenish sandstone, and limestone	2100–3200

The following divisions were made on the southwest limb of the syncline:

	Thickness (feet)
4. *Big Oak Flat shale and sandstone member.* Interbedded brownish sandstone and clay-shale, with limestone concretions, overlain by foraminiferal clay-shale	500– 700
UNCONFORMITY—	
2. *Call sandstone member.* Massive brownish concretionary sandstone	0–1200
1. *Paynes shale and sandstone member.* Interbedded dark-colored clay-shale, greenish sandstone, and limestone	5200–8500

An unconformity between units 2 and 4 above cuts out 1200 feet of the Call sandstone member within a horizontal distance of 1¼ miles. A difference in strike of 12° between the two members shows clearly on aerial photographs. The Butts Ranch shale member is not represented on the southwest side of the syncline. The Big Oak Flat shale and sandstone member cannot be placed definitely with respect to the sequence on the northeast limb of the syncline. It is thought to be younger than the Butts Ranch shale member because of its unconformable position on the Call sandstone member. The Panoche group of the Browns Valley area is not divisible into lithologic units, but most resembles the Paynes shale and sandstone member of the Butts Ranch syncline.

Paynes Shale and Sandstone Member

The Paynes shale and sandstone member is herein named for Paynes Creek, and the type locality is the section along Paynes Creek 2½ miles north of Butts Ranch, where the thickness is 2100 feet. A greater thickness of 5200 to 8500 feet is found on the southwest side of the Butts Ranch syncline. The type locality was chosen for the superior quality of the exposures of the member, and of its relationships to the surrounding beds. The member consists largely of interbedded dark-colored clay-shales, greenish sandstones, and limestones. The shales are typically greenish to black clay-shales or poorly sorted silty micaceous shales. They are well-bedded in layers ½ to 2 inches in thickness, and are commonly rhythmically interbedded with thin-bedded sandstone or limestone. Carbonaceous material is common. The sandstones are poorly sorted, arkosic and strongly biotitic, greenish to brownish in color. They occur in well-cemented beds a few inches to 3 feet in thickness. The limestones are generally grayish in color, and occur as concretions or in small lenses a fraction of an inch to a few inches in diameter.

In the middle of the section in the Browns Valley area a conglomeratic layer about 150 feet thick can be traced for at least half a mile. The pebbles are subrounded to well rounded, ½ to 18 inches in diameter, averaging 3 to 6 inches. They are chiefly of the pre-Franciscan type of porphyries and quartzites. A study of 100 pebbles revealed the following proportions:

Gray feldspar porphyry	45
Quartz-feldspar porphyry	12
Pink biotite-feldspar porphyry	1
White and pinkish-white quartzite	15
Black quartzite	6
Black chert	4
Milky vein quartz	1
Breccia (?)	6
Fine-grained granodiorite	1
Undetermined	9

In the section on Paynes Creek on the northeast side of the Butts Ranch syncline occurs a thin conglomerate layer of scattered pebbles in a sandstone matrix. About 6 to 10 pebbles are exposed per square foot. They are well rounded, average 1 to 2 inches in diameter, and are the usual pre-Franciscan porphyries, black cherts, and quartzites.

Fossils from Tres Pinos Creek, near the middle of the Paynes shale and sandstone member, were identified by F. M. Anderson as *Inoceramus whitneyi* Gabb, *Anisomyon meekii* Gabb, and *Baculites* sp. He states that these are probably Panoche (Upper Cretaceous) in age.

Numerous pearly shell fragments and Foraminifera occur in a fine-grained carbonaceous sandstone layer 400 feet below the top of the Paynes shale and sandstone member on Paynes Creek. Megafossils include *Meekia radiata* Gabb, *Inoceramus* sp., and an unidentifiable echinoid, ''probably a spatangoid'', according to Hubert Lyman Clark. The following Foraminifera occur at this locality:

Bathysiphon
Dentalina communis (d'Orbigny)
Eponides haidingerii (d'Orbigny)
Gaudryina crassaformis Cushman and Campbell
Glandulina manifesta Reuss
Globotruncana arca (Cushman)
Gyroidina sp.
Lenticulina navicula (d'Orbigny)
Lenticulina sublaevis Morrow
Lenticulina williamsoni (Reuss)
Marginulinopsis decurse-costata Thalmann
Marssonella oxycona (Reuss)
Nodosaria affinis Reuss
Robulus velascoensis (White)
Spiroplectammina anceps (Reuss)
Stensioina cf. excolata (Cushman)
Ventilabrella ornatissima Cushman and Church

A dark-colored clay-shale interbedded with sandstone on Salt Creek yielded the following Foraminifera:

Bolivina incrassata ? Reuss
Bolivinopsis clotho (Grzybowski)
Bulimina trinitatensis Cushman and Jarvis
Gaudryina crassaformis Cushman and Campbell
Gyroidina cf. florealis White
Silicosigmoilina californica Cushman and Church
Arenaceous Foraminifera

According to Lois T. Martin, these are indicative of the Panoche (Upper Cretaceous).

Call Sandstone Member

The Call sandstone member is best developed on the northeast side of the Butts Ranch syncline, where it has a thickness ranging from 2600 to 2900 feet. It is here named for the Call Mountains, and the type locality is the section exposed through the Call Mountains on Paynes Creek 2 miles north of Butts Ranch. The member is also exposed on the southwest side of the syncline at the head of Buckeye Canyon, where it has a thickness of only 1200 feet; it is cut out completely toward the east by the unconformity with the overlying Big Oak Flat member. No fossils were found in the Call sandstone member, but its age is delimited by fossiliferous Upper Cretaceous beds occurring on either side.

The member consists mainly of massive brownish concretionary sandstones, and some interbedded siltstones and clay-shale. The sandstones form prominent outcrops and cliffs. They are arkosic, poorly sorted, angular, and well cemented. In addition to quartz they contain abundant feldspars, biotite, and carbonaceous material. Heavy minerals present besides biotite are zircon, brown tourmaline, garnet, sphene, magnetite, and epidote. The sandstones have a grayish color when fresh, but are usually weathered brownish. They possess large reddish-brown ''cannonball'' concretions ranging from 2 to 10 feet in diameter.

Well-bedded siltstones and clay-shales are commonly interbedded with the sandstones of the Call sandstone member. The siltstones usually show fine banding caused by the orientation of biotite flakes and other dark minerals in thin layers. Many of the bands show cross-bedding, a feature of great aid in determining the top sides of the strata. Graded bedding is often present, passing from sandstone through siltstone to clay-shale, then starting abruptly again with sandstone. One of the most interesting features of the siltstone is the occurrence of intraformational contortion or corrugation (Hills 40, pp. 15-17) revealed by the dark banded layers. Some bands are extremely contorted into asymmetric overturned and recumbent folds 6 to 8 inches high, although the boundaries of the siltstone bed against the adjacent sandstone or shale remain parallel. The contortion is probably due to sliding or slumping while the siltstone still contained water and could act as a plastic mass.

A fairly persistent conglomerate about 100 feet thick occurs at the base of the Call sandstone member on the northeast side of the Butts Ranch syncline. The pebbles are subrounded to well rounded, averaging 3 to 4 inches in diameter. They consist of the pre-Franciscan group of porphyries, black cherts, and quartzites.

Butts Ranch Shale Member

The Butts Ranch shale member of the Panoche group is exposed only along the northeast limb of the Butts Ranch syncline. It is named for Butts Ranch, and the type locality is the section along Paynes Creek 1 mile north of Butts Ranch. Here it has a thickness of 200 feet.

This member consists of purplish or brownish calcareous and clay-shales, which are abundantly foraminiferal. The shales are thinly bedded, tend to be somewhat hard and platy, and are highly fractured. The shale member is cut at various angles by sandstone dikes 2 or 3 feet wide, composed of a brownish biotitic sandstone similar to the underlying Call sandstone member.

The Butts Ranch shale member yielded the following assemblage of well preserved Foraminifera:

Anomalina cf. rubiginosa Cushman
Bolivina incrassata Reuss
Bulimina obtusa d'Orbigny
Epistomina caracolla (Roemer)
Eponides haidingerii (d'Orbigny)
Gaudryina crassaformis Cushman and Campbell
Globotruncana arca (Cushman)
Gyroidina depressa (Alth)
Haplophragmoides eggeri Cushman
Lenticulina williamsoni (Reuss)
Marssonella oxycona (Reuss)
Nodosaria ewaldi Reuss
Nodosaria cf. spinifera Cushman and Campbell
Planulina cf. schloenbachi (Reuss)
Pullenia coryelli White var.
Silicosigmoilina californica Cushman and Church
Spiroplectammina anceps (Reuss)
Ventilabrella ornatissima Cushman and Church

The faunal assemblage from the Butts Ranch shale member has been examined by Louis Simon, C. C. Church, Max B. Payne, and Robert T. White, all of whom state that it is indicative of the Panoche, and is definitely older than the Moreno at its type area.

Big Oak Flat Shale and Sandstone Member

The Big Oak Flat shale and sandstone member, which unconformably overlies the Call sandstone member, is exposed only on the southwest side of the Butts Ranch syncline. It is named for Big Oak Flat, and the type locality is the small northeast-trending canyon 1 mile northwest of Big Oak Flat. Here were found Foraminifera which established its Upper Cretaceous age.

The relation of this member to the formations on the northeast limb of the syncline can not be established definitely. Because of the unconformity at its base, it is thought to be younger than the Butts Ranch shale member. It may also be younger than the Moreno shale, which does not appear on the southwest side of the syncline. The Foraminifera, beyond indicating an Upper Cretaceous age, are not sufficiently distinctive to correlate it more closely. The member is overlain by the Lodo formation (middle Eocene).

The member consists of interbedded sandstone and shale with limestone concretions, having a thickness of 300 to 350 feet, overlain by 200 to 300 feet of foraminiferal clay shale. The sandstones are brownish, well-cemented, poorly sorted, and arkosic, containing an abundance of biotite. They occur in resistant beds 2 to 3 feet thick, separated by sandy shale, siltstone, and dark-colored clay-shales. Limestone concretions are common, appearing dark gray to black on fresh exposure but weathering light gray. Some of them contain molds of undeterminable pelecypods and gastropods. The foraminiferal shale at the top is a well-bedded clay-shale, somewhat calcareous, chocolate-brown to black in color.

The Big Oak Flat shale and sandstone member contains an assemblage of mainly arenaceous Foraminifera:

Arenobulimina ?
Bathysiphon
Bulimina
Gaudryina
Globigerina
Glomospira charoides (Jones and Parker)
Haplophragmoides
Marssonella ?
Nonion ?
Plectina cf. irregularis Marsson
Pullenia
Silicosigmoilina californica Cushman and Church
Spirillina vivipara Ehrenberg
Spiroloculina cretacea Reuss
Spiroplectammina dentata (Alth)
Trochammina globigeriniformis (Parker and Jones)
Trochamminoides
Radiolaria ? Lithostrobus

The slide containing this faunule was examined by Louis Simon, who states: "My guess would be that your faunule is from the Upper Cretaceous probably not older than basal Coniacian."[4]

Moreno Shale (Upper Cretaceous)

The Moreno shale (Anderson and Pack 15, p. 46) is exposed in a narrow belt along the northeast side of the Butts Ranch syncline where it has a thickness of 300 to 650 feet. It is typically a purple thin-bedded platy siliceous and calcareous shale, interbedded with soft brownish clay-shale. Gray limestone concretions up to 6 feet in diameter are common. These contain numerous specimens of the foraminifer *Siphogenerinoides* which may readily be noticed by the naked eye. The shale is cut at random by sandstone dikes from 2 to 10 feet wide. These dikes are composed of a brownish arkosic biotitic sandstone, identical with and probably derived from the underlying sandstones of the Panoche group. A few thin-bedded brownish sandstones are occasionally interbedded with the shale. The Moreno shale forms a low belt of gently rounded grass-covered slopes, and supports a few oak trees, but no chaparral. It contrasts strongly with the overlying Call sandstone member which forms resistant slopes and is covered by chaparral.

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[4] Letter to H. G. Schenck dated February 10, 1941.

The Moreno shale appears to rest conformably upon the Call sandstone member of the Panoche group along the northeast side of the Butts Ranch syncline.

The relationships to the Butts Ranch shale member and Big Oak Flat shale and sandstone member of the Panoche are in some doubt, as these are nowhere in contact with the Moreno. The Butts Ranch shale member also rests depositionally upon the Call sandstone member on the northeast side of the Butts Ranch syncline, farther south along Paynes Creek. The foraminiferal evidence indicates that it is older than Moreno. It is lithologically similar to the Moreno, and may actually be included in the lower part of the unit which was mapped as Moreno, although no faunal evidence for its presence there was found. The Big Oak Flat shale and sandstone member occurs only on the southwest side of the Butts Ranch syncline, where the Moreno is not exposed. It may actually be younger than the Moreno.

The Moreno shale contains abundant Foraminifera, belonging to a relatively few species:

Bulimina cf. prolixa Cushman and Parker
Cyclammina elegans Cushman and Jarvis
Cyclammina pusilla Brady
Haplophragmoides eggeri Cushman
Siphogenerinoides cf. whitei Church

These species, particularly the *Siphogenerinoides,* are characteristic of the type Moreno, Upper Cretaceous, according to H. G. Schenck and Max B. Payne. They state that the lithology and fauna at this locality correspond to the Marca shale member (Payne 41) of the Moreno at the type locality.

Los Muertos Creek Formation (Middle Eocene)

The name Los Muertos Creek formation is proposed for a series of siltstones, fine-grained buff micaceous sandstones, clay-shales, and cherty shales exposed 2 miles northwest of Los Muertos Creek, west of Brown Valley, in the northwestern part of the San Benito quadrangle. The formation has an exposed thickness of about 1000 feet. It is exposed in a narrow belt trending northwest for a distance of 2 miles within the quadrangle. The base is faulted out against the Panoche group to the northeast. Los Muertos Creek formation is conformably overlain by the Tres Pinos sandstone to the southwest, and is overlapped to the southeast by the San Benito gravels. Fossils indicate that it belongs to the Capay stage, middle Eocene.

The formation consists chiefly of buff to brownish fine-grained sandstones and siltstones which are poorly indurated, highly jointed, and strongly weathered. The sandstones are somewhat clayey and micaceous. Near the top of the section there are a few layers 3 to 4 feet wide of massive, well-cemented, coarse-grained quartzose sandstone which are much more resistant to erosion than the rest of the formation. These are lithologically identical with the overlying Tres Pinos sandstone. Dark-colored clay-shales are occasionally interbedded with the sandstones. Toward the bottom of the exposed section, in the northeast corner of the Gonzales quadrangle, are some platy cherty shales, in beds 2 to 8 inches thick. Foraminifera were revealed by the handlens, but they could not be separated from the hard shale for microscopic examination.

The formation is easily eroded, and forms low, well-rounded grass-covered slopes. It is poorly exposed except in canyons. It contrasts strongly with the overlying Tres Pinos sandstone which forms high resistant knobs exhibiting bare rock surfaces.

Abundant but poorly preserved fossils were found at one locality in a brownish siltstone in Los Muertos Creek formation. The following were identified by B. L. Clark and the writer:

ANTHOZOA
- Turbinolia sp.

ECHINOIDEA
- Schizaster diabloensis Kew

PELECYPODA
- Gari ? sp.
- Glycymeris ? sp.
- Nemocardium linteum (Conrad)
- Pitar sp.
- Plagiocardium (Schedocardia) brewerii hartleyense? (Clark and Woodford)
- Solen sp.
- Solena ? sp.
- Trachycardium (Agnocardia) sorrentoense ? (Hanna)
- Yoldia rosa ? (Hanna)

GASTROPODA
- Amaurellina ? sp.
- Bittium dumblei ? (Dickerson)
- Ficopsis remondii (Gabb) crescentensis Weaver and Palmer
- Turritella uvasana Conrad subsp.

ARTHROPODA
- fragment of Crustacean

B. L. Clark states that this assemblage belongs to the Capay stage of the middle Eocene.

The formation just described was assigned to the Meganos formation by Kerr and Schenck (25, p. 475), but this was before the Capay stage had been separated in the California Eocene. H. G. Schenck, who has examined the above faunal list, agrees that the formation might fall in the ''Capay stage.'' A local formational name is preferred because there is no assurance that future subdivisions or groupings of the California Eocene may not place this assemblage of strata in some other stage, and, according to Schenck, the stratigraphic relations of the type Capay are not certain.

Tres Pinos Sandstone (Middle Eocene)

The Tres Pinos sandstone is a massive resistant coarse-grained quartzose sandstone exposed in a belt immediately overlying Los Muertos Creek formation northwest of Los Muertos Creek. The exposed thickness is about 900 feet, but the top of the formation is concealed by overlapping terrace deposits to the southwest and the San Benito gravels to the southeast. The sandstone is resistant to erosion, forming prominent ridges and knobs with bare rock surfaces. It supports a sparse growth of brush of the sagebrush type in addition to grass. A conglomerate occurs at the base containing fossils of Capay (middle

Eocene) age; however, the rest of the formation is non-fossiliferous and may be slightly younger. The formation was named by Kerr and Schenck (25; pp. 470-475) and the type locality was apparently the section herein described.

The Tres Pinos consists entirely of well-cemented and resistant sandstone and conglomerate. The sandstone is whitish on fresh exposure, but weathers to a buff or brownish color. It occurs in massive beds 10 to 15 feet thick, which are jointed and contain large erosional cavities. The sandstone contains abundant quartz and subordinate feldspar in subangular to subrounded grains. A mineral analysis reveals zircon to be the most abundant heavy mineral, making up half or more of the heavy portion. Brown biotite and garnet are next in abundance. The presence of a small amount of glaucophane indicates the Franciscan as either a direct or reworked source for the formation. Chlorite, epidote, green hornblende, magnetite, picotite, rutile, sphene, and tourmaline are also present. The analysis is most nearly similar to one of the Yokut sandstone of the Butts Ranch syncline; except for the presence of glaucophane.

At the base of the formation is a well-cemented calcareous buff conglomeratic sandstone layer 10 to 15 feet thick which contains abundant poorly preserved fossils. This is a persistent horizon which was traced for 1½ miles. It contains small pebbles, averaging ⅛- to ½-inch but ranging up to 3 inches in diameter. They consist chiefly of milky quartz, black chert, and gray limestone.

The Tres Pinos sandstone is barren of fossils except for the basal conglomerate, from which the writer collected chiefly poorly preserved pelecypods, including *Pitar* sp. A better collection of gastropods made by H. G. Schenck in 1924 was loaned to the writer, and identified by B. L. Clark as follows:

GASTROPODA
- Rimella (Macilentos) macilenta White
- Amaurellina clarki Stewart
- Turritella andersoni Dickerson
- Cryptochorda californica Cooper

These are indicative of the Capay stage, according to Clark. This fossiliferous conglomerate horizon was included by Kerr and Schenck (25, p. 475) in the formation immediately below the Tres Pinos, called by them Meganos, and herein named Los Muertos Creek formation. To the writer, however, it seems more proper to consider this horizon as the basal conglomerate of the Tres Pinos sandstone, because it is overlain by a series of sandstones which are similar to the matrix of the conglomerate. Since the contact is conformable and gradational, however, its placement is necessarily more or less arbitrary. The gradational character is indicated by the fact that a few sandstone layers similar to the Tres Pinos occur within the top portion of Los Muertos Creek formation.

Although the age of the basal conglomerate is established as Capay, the rest of the sandstone could be somewhat younger, in the lack of any faunal evidence. The formation cannot be correlated with certainty with any of the Butts Ranch syncline section. It is lithologically most nearly similar to the Yokut sandstone; however, it might be equivalent to the Domengine sandstone.

Lodo Formation (Middle Eocene)

The Lodo formation (White 38) is represented by about 300 feet of bluish-gray foraminiferal clay-shale occurring in a narrow belt along the southwest side of the Butts Ranch syncline. It is poorly exposed except in a small canyon running northeast of Hill 3603 on Pine Ridge. Here Foraminifera which establish its age were collected.

The shale of the Lodo formation directly overlies the Big Oak Flat shale and sandstone member of the Panoche group. No actual contact between the two similar shale units was seen, and the boundary was arbitrarily placed between foraminiferal collecting localities establishing the age of the two formations. The Lodo is overlain, apparently conformably, by the Yokut sandstone. The contact is sharply defined, but there is no apparent difference in attitude of the two formations.

The Lodo formation offers slight resistance to erosion, and, together with the underlying Cretaceous shale, forms a low trough between the more resistant Yokut sandstone to the northeast and the Cretaceous sandstone along Pine Ridge. It supports a fairly dense growth of brush of the scrub-oak type.

The following is a foraminiferal assemblage from near the top of the Lodo formation:

Anomalina aragonensis Nuttall
Anomalina garzaensis Cushman and Siegfus
Asterigerina crassaformis Cushman and Siegfus
Bathysiphon eocenica Cushman and Hanna
Bolivinopsis directa (Cushman and Siegfus)
Bulimina cf. callahani Galloway and Morrey
Discorbis allomorphinoides (Reuss) of Plummer
Gaudryina coalingensis Cushman and Hanna
Globigerina bulloides d'Orbigny
Globigerina triloculinoides Plummer
Globorotalia n. sp.
Globorotalia crassata (Cushman)
Glomospira charoides corona Cushman and Jarvis
Gyroidina octocamerata Cushman and Hanna
Nodosarella ignota Cushman and Siegfus
Nonion wilcoxensis Cushman and Ponton
Pleurostomella cubensis Cushman and Bermudez
Pleurostomella nuttalli Cushman and Siegfus
Silicosigmoilina californica Cushman and Church

According to H. G. Schenck, this faunule is to be correlated with a part of the type Lodo formation, or with division C of the Eocene classification of Laiming (40, pp. 550-551). The age is middle Eocene, approximately equivalent to the ''Capay stage.''

Yokut Sandstone (Middle Eocene)

The Yokut sandstone is a massive quartzose sandstone unit exposed along the southwest flank of the Butts Ranch syncline. Its thickness varies between 800 and 1200 feet. It conformably overlies the Lodo formation, and is unconformably overlain by the Domengine sandstone.

The formation is resistant to erosion, forming prominent outcrops, and is covered by a dense growth of chaparral (chamise and manzanita), particularly on the southerly slopes.

The sandstone is unfossiliferous, but its position between two fossiliferous horizons establishes its age as middle Eocene, probably equivalent to part of the Capay stage. Similar lithologic character and position in the sequence form the bases of correlation with the type Yokut, named by Robert T. White (40). The type locality is on the west side of the San Joaquin Valley north of Coalinga.

The Yokut consists nearly entirely of sandstone, which is well cemented and resistant, and shows tendencies toward cavernous weathering. In places it is concretionary, bearing brownish sandstone concretions several feet in diameter. It is predominantly massive, but sometimes shows bedding planes spaced 10 to 15 feet apart. The sandstone is whitish on fresh exposures but weathers yellowish to brownish. It is better sorted than most of the sandstones in this region. The grains are subangular to subrounded, medium- to coarse-grained. The sandstone is quartzose, somewhat feldspathic, but relatively poor in biotite and other ferromagnesians. A mineral analysis reveals a paucity of heavy minerals, of which zircon is most abundant. Present in lesser quantities are garnet, sphene, brown tourmaline, epidote, magnetite, and chlorite.

Domengine Sandstone (Middle Eocene)

The Domengine sandstone (Anderson 05, pp. 167-168; Clark and Stewart 25), middle Eocene, is one of the most characteristic and readily mappable horizons of the Butts Ranch syncline. It is nearly everywhere abundantly fossiliferous, which distinguishes it from the adjacent formations. It occurs on both sides of the syncline, from the eastern edge of the quadrangle to Salt Creek, where it is overlapped by the Etchegoin group and San Benito gravels. The thickness is comparatively uniform, varying but little from 200 feet. The sandstone is resistant to erosion, and characteristically forms a narrow topographic ridge, with troughs or saddles on either side. It is covered by oaks and grass like the overlying Kreyenhagen shale, but usually the concentration of oaks is greater than on the shale.

The Domengine is typically a fine- to medium-grained well-cemented calcareous sandstone, gray to whitish on fresh exposure, but weathering yellowish brown. It may be massive, or bedded in layers 2 to 3 feet thick. In general it seems finer-grained, more calcareous, and less quartzose than the underlying Yokut sandstone. Three mineral analyses reveal a variety of heavy minerals. These include glaucophane, zircon, hypersthene, magnetite, garnet, biotite, chlorite, augite, brown tourmaline, rutile, and sphene. This assemblage, particularly the glaucophane, is indicative of a Franciscan source at least in part.

At the base of the Domengine is one of the most important unconformities in the Butts Ranch synclinal section. This is shown not so much by a difference in dip with the underlying formations, which cannot be readily determined, but by its profound overlapping onto strata of different ages. On the south side of the syncline the Domengine rests upon the Yokut sandstone, the next oldest formation. But on the north side of the syncline it rests alternately upon the Butts Ranch shale and the Call sandstone members of the Panoche group. On the same limb of the syncline, farther east in Moody Gulch it again lies upon the Yokut. The Domengine shows similar overlapping relations at various places along the west side of the San Joaquin valley.

The Domengine sandstone is abundantly fossiliferous, although the forms are usually poorly preserved. The fauna so far collected is exclusively molluscan, divided about equally between pelecypods and gastropods, except for one coral, a *Turbinolia*. The most diagnostic as well as most abundant fossil is *Turritella buwaldana*, which was found at nearly every locality. This is taken to be characteristic of the Domengine, middle Eocene.

The fauna, identified by H. G. Schenck and the writer, is indicated in the following list:

ANTHOZOA

Turbinolia sp.

PELECYPODA

Crassatella uvasana (Conrad) semidentata ? (Cooper)
Crassatella ? sp.
Glycymeris sp.
Macrocallista sp.
Miltha (Eomiltha) packi ? (Dickerson)
Nemocardium linteum (Conrad)
Nemocardium cf. marysvillense (Dickerson)
Nuculana chaneyi ? Vokes
Nuculana gabbii (Gabb)
Nuculana sp.
Ostrea ? sp.
Pitar avenalensis ? Vokes
Pitar joaquinensis Vokes
Pitar sp.
Plagiocardium (Schedocardia) brewerii ? (Gabb)
Plagiocardium (Schedocardia) sp.
Solen domengenicus ? Vokes
Solen sp.
Trachycardium ? sp.
Venericardia sp.

GASTROPODA

Amaurellina caleocia Vokes
Conus hornii Gabb umpquaensis Hendon
Conus sp.
Cylichnina tantilla ? (Anderson and Hanna)
Cylichnina sp.
Domenginella ? sp.
Ficopsis remondii (Gabb) crescentensis Weaver and Palmer
Molopophorus ? sp.
Pachycrommium clarki ? (Stewart)
Pachycrommium ? sp.
Polinices hornii (Gabb)
Rimella (Macilentos) macilenta White
Scaphander (Mirascapha) costatus (Gabb)
Surculites matthewsonii ? (Gabb)
Turritella buwaldana Dickerson

Kreyenhagen Shale (Upper Eocene)

The Kreyenhagen shale (Anderson 05, pp. 163-168) is a group of foraminiferal calcareous, siliceous, and clay-shales, with some interbedded sandstone and limestone, which occurs on both limbs of the Butts Ranch syncline. The northeast limb has a thickness of 400 to 1800 feet, the southwest limb 1500 to 2500 feet. The shale is less resistant to erosion than the adjacent formations, although the individual members vary in this respect. It supports oaks and grass on southerly slopes, and brush of the scrub-oak type on northerly slopes. The latter grows most profusely on platy siliceous shales in the upper part of the section.

The Kreyenhagen shale in this area rests everywhere upon the Domengine sandstone with apparent conformity. The nearly constant thickness of the relatively thin Domengine sandstone horizon over a broad area seems good evidence for the absence of any appreciable erosional interval prior to deposition of the Kreyenhagen.

The most complete section of the Kreyenhagen, on the southwest side of the Butts Ranch syncline, shows the following units:

	Thickness (feet)
3. Upper member. Siliceous and calcareous foraminiferal platy shales, with some limestone	500–1500
2. Bear Canyon sandstone member. Buff to brownish massive sandstone	100– 300
1. Foraminiferal clay-shales and platy shales, with some interbedded sandstone and limestone, and a thin glauconitic sandstone at the base. Equivalent to Canoas siltstone member of Coalinga district	300–1000

The only unit which was mapped separately is the Bear Canyon sandstone member. This member does not occur on the northeast side of the syncline, and here no sharp division between units 1 and 3 was found, hence the latter were not distinguished on the map as cartographic units.

Canoas Member

The lower third of the Kreyenhagen on both sides of the Butts Ranch syncline is faunally equivalent to the Canoas siltstone member of the Coalinga district (Cushman and Siegfus 42, pp. 390-391).

The base is usually marked by a thin glauconitic sandstone layer ranging from a few feet to 50 feet thick. In places this rock contains more than 50 percent glauconite.

The rest of the member consists of foraminiferal gray to brown clay-shales and some platy calcareous and siliceous shales. Occasional yellowish limestones and buff to brownish poorly indurated sandstones are interbedded with the shales.

Bear Canyon Sandstone Member

The term Bear Canyon sandstone member is proposed for a persistent sandstone occurring about one-third of the distance above the base of the Kreyenhagen on the southwest side of the Butts Ranch syncline. The type locality is designated as Bear Canyon, 1 mile north of Big Oak Flat. The sandstone has a thickness of 100 to 300 feet. It is fine- to medium-grained, micaceous, gray on fresh exposure, but weathering buff to brownish; moderately to well indurated. No fossils were found in the sandstone. It is more resistant to erosion than the adjacent shales, and supports a somewhat denser growth of oak trees, by which it may be followed over part of its course on the aerial photographs.

Upper Member

The upper two-thirds of the Kreyenhagen shale consists of platy siliceous and calcareous shales, containing abundant Foraminifera and Radiolaria; and some interbedded clay-shales. The platy shales commonly weather white, but appear chocolate brown on fresh exposures. Some of them are fairly resistant to erosion. Toward the lower part of this member are some yellowish-weathering limestones, in beds 2 to 3 feet thick.

Fossils, Correlation, and Age

Foraminifera are abundant at various horizons in the Kreyenhagen shale. The following collection was made from the Canoas member on the southwest side of the Butts Ranch syncline:

Anomalina crassisepta Cushman and Siegfus
Anomalina garzaensis Cushman and Siegfus
Asterigerina crassaformis Cushman and Siegfus
Bulimina n. sp.
Cibicides n. sp.
Cibicides pygmaeus (Hantken)
Cibicides venezuelanus Nuttall
Dorothia eocenica Cushman
Eponides sp.
Eponides minimus Cushman
Marginulina asperuliformis (Nuttall)
Marginulina subbullata Hantken
Plectina garzaensis Cushman and Siegfus
Pleurostomella nuttalli Cushman and Siegfus
Pullenia eocenica Cushman and Siegfus
Robulus welchi Church
Silicosigmoilina californica Cushman and Church
Tritaxilina pupa (Gümbel) of Cushman
Vulvulina curta Cushman and Siegfus

H. G. Schenck states that this assemblage is equivalent to the Canoas member of the Kreyenhagen, or to the A-2 zone of Laiming (40, pp. 544-545).

A less distinctive assemblage from the northeast side of the syncline, 50 feet above the base, was identified as follows:

Cyclammina sp.
Haplophragmoides eggeri Cushman
Silicosigmoilina californica Cushman and Church

The upper part of the Kreyenhagen shale contains a different foraminiferal assemblage. The following were collected about 400 feet above the base, on the northeast side of the Butts Ranch syncline:

Amphimorphina sp.
Anomalina cf. dorri Cole
Asterigerina cf. crassaformis Cushman and Siegfus
Bathysiphon eocenica Cushman and Hanna
Bulimina corrugata Cushman and Siegfus
Cibicides venezuelanus Nuttall
Cibicides sp.
Cyclammina sp.
Dentalina sp.
Dorothia principensis Cushman and Bermudez
Dorothia sp.
Eponides cf. umbonatus (Reuss) of Cushman
Eponides sp. 1
Eponides sp. 2
Glandulina sp.
Gyroidina sp.
Gyroidina octocamerata Cushman and Hanna
Lenticulina sp.
Nodogenerina sp.
Nodosarella sp. 1
Nodosarella ? sp. 2
Nodosaria arundinea Schwager of Cushman and Hanna
Nodosaria consobrina d'Orbigny of Cushman and Hanna
Nodosaria sp. 1
Nodosaria sp. 2
Plectofrondicularia aff. cookei Cushman
Pleurostomella sp.
Pulvinulinella tenuicarinata Cushman and Siegfus
Robulus sp. 1
Robulus sp. 2
Robulus sp. 3
Robulus sp. 4
Robulus sp. 5
Spiroplectammina ? sp.
Spiroplectoides californica Cushman and Campbell
Uvigerina garzaensis Cushman and Siegfus
Virgulina sp.
Vulvulina curta Cushman and Siegfus

H. G. Schenck, who examined the slide containing these Foraminifera, states: "I feel fairly certain that your faunule is younger than those commonly referred to as 'Canoas.' The assemblage is thus younger than the basal Kreyenhagen north of Coalinga, but older than the upper Kreyenhagen or Tumey sandstone and shale of the same district."[5]

Temblor Group (Middle Miocene)

The Temblor group (Anderson 05, pp. 168-187) is represented in the San Benito quadrangle by three mappable units: a lower sandstone, 100 to 500 feet thick; a shale in the middle of the section, 300 to 1000 feet thick; and an upper sandstone, 400 feet thick. They are exposed along the axis of the Butts Ranch syncline, and are the youngest rocks affected by the folding of the syncline. The three members are conformable with one another. The lower member rests disconformably upon the Kreyenhagen shale, judging from the following evidence:

1) The great variation in thickness of the underlying Kreyenhagen shale and its apparent overlap by the Temblor in some places. For example, in the extreme northwest part of the syncline all but 400 feet of the Kreyenhagen is overlapped.

2) The absence of true Vaqueros ("lower Miocene") deposits in the area.

No significant difference in attitude between the two formations could be measured, but little reliance was placed on determinations in the easily slumped shales of the Kreyenhagen.

The Temblor sandstones are more resistant to erosion than the middle shale, and form slight topographic ridges separated by a comparatively low, gently rounded belt. The shale supports oaks and grass on southerly slopes, dense brush of the scrub-oak type on northerly slopes, and chaparral (chamise and manzanita) on some of the southerly slopes.

Temblor Lower Sandstone

The Temblor lower sandstone consists chiefly of gray, buff, or brownish poorly cemented sandstones, which are occasionally fossiliferous, and a well-cemented calcareous gray fossiliferous "reef" bed at the top of the section. This "reef" bed, which occurs immediately below the Temblor shale, is a distinctive lithologic unit. It was traced for at least 3½ miles along the southwest side of the syncline, and was also found for a short distance on the northeast side. The "reef" bed is packed with Pseudocardiums and an undescribed species of *Chlamys*, and contains occasional gastropods.

The sandstones lying below the "reef" bed are poorly sorted, fine- to coarse-grained, consisting of subangular grains of quartz, feldspars, rock fragments, biotite, and other ferromagnesians. Heavy minerals present include epidote, garnet, magnetite, rutile, tourmaline, and zircon. Bedding is poorly shown. Occasional pebbly beds occur, containing small pebbles ¼- to ½-inch in diameter of chiefly Franciscan debris, including sandstone, chert, and glaucophane schist. The pre-Franciscan porphyries, black cherts, and quartzites are also present.

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[5] Letter dated April 10, 1940.

Poorly preserved mollusks occur sparsely at various places in the Temblor lower sandstone, but are abundant in the "reef" bed at the top. *Mytilus expansus* and *Pseudocardium* sp. are the most abundant fossils. A small, many-ribbed *Chlamys* is common in the "reef" bed, but it belongs to an undescribed species, according to B. L. Clark, L. G. Hertlein, and H. G. Schenck, all of whom have examined it. The most distinctive forms are *Bruclarkia oregonense* and *Turritella inezana* var. L. G. Hertlein, who examined the faunule, believes that it is equivalent to the "Vaqueros-Temblor transition stage" of Loel and Corey (32), or "lower-middle Miocene."

The fossils in the following list were determined by L. G. Hertlein, H. G. Schenck, and the writer.

ANTHOZOA

Undetermined

PELECYPODA

Antigona sp.
Chlamys n. sp.
Clementia ? sp.
Crassatellites ? sp.
Glycymeris aff. branneri Arnold
Glycymeris sp.
Lucina ? sp.
Mytilus expansus Arnold
Ostrea titan (Conrad) subtitan ? Loel and Corey
Pachydesma sp.
Panope estrellana Conrad
Pseudocardium sp.
Solen gravidus ? Clark
Spisula abbotti ? Wiedey
Tellina sp.

GASTROPODA

Bruclarkia oregonense (Conrad)
Calyptraea costellata (Conrad)
Polinices ? sp.
Thais ? sp.
Tritonalia ? sp.
Turritella inezana (Conrad) var.

CIRRIPEDIA

Balanus sp.

MISCELLANEOUS

Teredo borings in wood

Temblor Shale

The Temblor shale consists of hard platy siliceous and calcareous foraminiferal shales, and a few clay-shale partings. The platy shales are chocolate brown on fresh exposure, but weather white. They sometimes show a rhythmic banding, in addition to a well-developed bedding in layers 2 to 3 or sometimes 6 to 8 inches thick. A few fine-grained sandstone and sandy shale layers are interbedded with the platy shales.

Foraminifera are fairly abundant in the Temblor shale, but because of its hard siliceous nature determinable specimens could not be washed out. Determinations in the unwashed shale were made by H. G. Schenck as follows:

Bathysiphon ? sp.
Dentalina sp.
Plectofrondicularia sp.
Plectofrondicularia miocenica ?
Uvigerina ? sp.

The shale contains, besides Foraminifera, abundant fish scales and a few mud pectens. The latter were determined by H. G. Schenck as *Delectopecten* aff. *peckhami* (Gabb).

Although none of these fossils are sufficiently distinctive for an age determination, the position of the shale between the Temblor lower sandstone and upper sandstone establishes its age as Temblor (middle Miocene). The fossils are not incompatible with this determination.

Temblor Upper Sandstone

The Temblor upper sandstone consists of massive, friable, gray to yellowish sandstones and occasional intercalated shale layers. The sandstone is poorly sorted, medium- to coarse-grained, consisting of angular to subangular grains of feldspars, quartz, biotite, other ferromagnesians, and numerous rock fragments. A few pebbly layers occur, containing chiefly Franciscan pebbles, and a few of the pre-Franciscan group.

Mineral analysis reveals a great variety of heavy minerals, including such comparatively unusual varieties as andalusite and idocrase. In greatest abundance are green hornblende, brown biotite, and augite; there are smaller amounts of green biotite, magnetite, zircon, garnet, epidote, glaucophane, muscovite, and sphene. Volcanic glass is rare; when present, it has a refractive index of 1.506±.004, indicating a silica content of about 70 percent (George 24).

Mollusks are scarce and usually poorly preserved in the Temblor upper sandstone. The common forms are similar to those occurring in the Temblor lower sandstone, exclusive of the "reef" bed. Perhaps the most diagnostic species is *Bruclarkia oregonense.*

The best evidence for the Temblor age occurs along the easterly extension of the formation in the Panoche quadrangle, where Mielenz (39, p. 167) found specimens of *Echinarachnius merriami* (F. M. Anderson). This occurs with *Turritella ocoyana* Conrad in the northeastern end of the Vallecitos (Anderson and Pack 15, p. 86). Both species are believed to be good markers of the Temblor formation.

The following species were determined in the Temblor upper sandstone:

PELECYPODA

Mytilus expansus Arnold
Ostrea sp. (large)
Pachydesma gabbi (Clark)
Panope estrellana (Conrad)
Solen sp.
Tagelus sp.

GASTROPODA

Bruclarkia oregonense (Conrad)
Calyptraea costellata (Conrad)
Olivella ? sp.
Polinices ? sp.

Miocene Volcanics

A great series of Miocene rhyolite flows, dikes, and pyroclastics, and a few more basic flows, is located in the Gabilan Range in the southern part of the San Benito quadrangle. The main volcanic area lies in the Pinnacles National Monument, extending north about a mile into the San Benito quadrangle. Another center of eruption lies farther north in the Willow Creek region, and smaller patches of volcanics are exposed between these areas. Miocene volcanics are widespread in the Coast Ranges, but this is perhaps the largest area in which rhyolite is the dominant rock, and the largest area of subaerial explosive eruptions.

Rhyolite flows were erupted first, and were followed in places by more basic flows in small quantities. Then came a series of great explosive eruptions which produced thick deposits of rhyolite breccia, tuff, and agglomerate, called the Pinnacles formation (Andrews 36). These were followed near the north end of the Pinacles National Monument by another smaller flow of rhyolite. The volcanics have the following thicknesses in the San Benito quadrangle:

	N. end of Pinnacles	*Willow Creek area*
Upper rhyolite flows	700	----
Pinnacles formation (volcanic breccia)	2600	700–1000
Lower rhyolite flows	1000	700

Rhyolite Flows

The rhyolites are generally white or gray, occasionally pink, lavender, or green. They show marked flow-banding, which is often strongly contorted and wrinkled. They have a small number of phenocrysts, only an occasional flake of biotite or grain of quartz being distinguishable with a lens. Microscopically they are seen to be very finely porphyritic, containing occasional small crystals of quartz, untwinned feldspar (sanidine and albite), brown biotite, apatite, magnetite, and zircon. The groundmass is aphanitic to glassy, showing a mass of microspherulites and a ''pepper and salt'' aggregate of fine-grained quartz and untwinned feldspar. The microspherulites, sometimes brownish in color, average 0.1 to 0.2 mm in diameter, and show negative elongation of the fibers. Masses of volcanic glass, usually partially devitrified, occur with the rhyolite.

The rhyolite is resistant and forms bold, projecting outcrops. A prominent feature of the landscape is Willow Creek Peak, a saddle-shaped mountain of rhyolite dipping steeply toward the west, with a cliff and talus slope on the eastern face. The rhyolite is covered by low brush of the sagebrush type or by chaparral.

Columnar joining is well developed southwest of Willow Creek Peak. The joints lie at right angles to flow-banding tilted 80° to the west. The columns are five- and six-sided, have an average diameter of 1 to 2 feet, and a length of 6 feet. Jointing elsewhere in the rhyolite has aided in formation of many cliffs.

Basic Flows

Some basic flows are exposed above the rhyolite, immediately below the Pinnacles formation, on Chalone Creek. These are colored dark red to black. A specimen of one of these flows, examined under the microscope, proved to be a quartz basalt containing xenocrysts of quartz and plagioclase up to 2 mm in diameter, probably derived from the underlying granite. The quartz xenocrysts are surrounded by reaction rims of chlorite. The major part of the rock is microcrystalline, subtrachytoid, consisting of plagioclase ($Ab_{50}An_{50}$), augite, brown biotite, hypersthene (partially altered to serpentine and hematite), magnetite, ilmenite, and zircon.

Small flows of dense black basalt occur intercalated with the Pinnacles formation on Willow Creek, in sec. 30, T. 15 S., R. 7 E., M. D.

Rhyolite Dikes

Numerous rhyolite dikes cut the Santa Lucia granite in the southwestern part of the quadrangle, west of the Pinnacles fault and south of Bickmore Canyon. They range in width from a few feet up to 600 feet, averaging 100 or 200 feet, and range in length from a few tens of feet up to 2 miles. They are intruded in a definite pattern along fractures which have an average strike of N. 30° W., and dip of 55° to 65° NE. Very few dikes have a trend differing from this. Some of the fractures have en echelon relationships.

The rhyolite in the dikes differs from that of the flows in that it generally lacks flow-banding and is more noticeably porphyritic. Small phenocrysts of quartz, orthoclase, and biotite may generally be seen with a lens. The groundmass is aphanitic to microcrystalline, made up largely of an aggregate of quartz and orthoclase, with subordinate oligoclase, biotite, muscovite, and magnetite. In some of the larger dikes the rock is very coarsely porphyritic. The central part of a 600-foot-thick dike on Chalone Creek contains phenocrysts of orthoclase up to an inch in diameter and quartz $\frac{1}{4}$-inch in diameter. This, however, is an unusual occurrence. Some of the dikes have a composition closer to that of dacite than rhyolite. These are colored dark gray and have phenocrysts of quartz, plagioclase, and biotite. A few more basic dikes, possibly of andesitic composition, were also seen.

The dikes commonly have a marked system of joints parallel with the fractures along which they were intruded, and one or more sets at right angles thereto. More resistant than the adjacent granite, they stand up as prominent ridges. They support a growth of chaparral or low brush of the sagebrush type.

Pinnacles Formation

The Pinnacles formation is a thick sequence of rhyolitic pyroclastic deposits, chiefly volcanic breccia, with some tuff and agglomerate. It was named by Andrews (36, p. 19) for exposures in the Pinnacles National Monument, where it reaches a thickness of 2600 feet. A separate belt 700 to 1000 feet thick occurs in the Willow Creek area, extending northwest for a distance of 5 miles. Smaller faulted blocks of the breccia are exposed on either side of Bear Valley.

The formation is coarsely stratified, and consists almost entirely of angular fragments of rhyolite, both flow-banded and massive, averaging 1 to 3 inches in diameter, in a tuffaceous matrix. Microscopically the matrix is seen to be composed of finely comminuted rhyolite fragments, with fewer fragments of quartz, untwinned feldspar, and glass, some of which is devitrified. The matrix sometimes reveals microspherulites.

The deposits show considerable variation. The fragments range in size from ash up to blocks 6 feet or more in diameter. Some of the beds containing larger fragments could be called agglomerate. There are also some beds of lapilli-tuff and tuff-breccia. The fragments are ordinarily angular, but in a few places some rounding is seen. At one locality on Willow Creek spindle-shaped vesicular bombs 8 inches in diameter occur in a tuffaceous matrix.

The only nonvolcanic fragments are some derived from the underlying granite. These are not scattered uniformly through the formation but are concentrated in single beds. One such bed containing abundant angular to subangular fragments of granite 4 to 6 inches in diameter occurs near the top of the formation at the north end of the Pinnacles National Monument. Where the formation rests directly on granite in the Willow Creek area fragments of granite are common in the basal portion. Some of these are boulders 5 or 6 feet in diameter, and in places it appears that the volcanic material was deposited on a residual breccia formed on the granite surface. However, in much of the formation granite fragments are entirely absent.

The Pinnacles formation is strongly jointed. Weathering and erosion along vertical joints have produced the many spires, crags, and steep cliffs which provide the scenic beauty and the name for the Pinnacles National Monument. In some places the joints have been enlarged into crevices, which have later been partially covered by large blocks tumbled from the cliffs on either side, to form caves. The formation supports a sparse growth of vegetation, mainly low brush of the sagebrush type or scattered chamise, and occasional pines.

The origin of the Pinnacles formation hinges upon the following characteristics: (1) the fragments are not waterworn; this eliminates the possibility of breccias resulting from transportation by water; (2) the fragments are chiefly of flow-banded or massive non-vesicular rhyolite; hence they must have been nearly solid before they were blown out; this eliminates the péléan type of eruption; (3) the material shows some stratification.

The type of volcanic eruption to which these characteristics seem most applicable is the vulcanian type. This is the opinion of Howel Williams, who examined the formation in the Willow Creek area in company with the writer. Periods of quiescence between eruptions produced stratification of the deposits.[6]

Some variation from this type of eruption is evidenced by the small deposit observed on Willow Creek in which spindle-shaped vesicular bombs occur in a tuffaceous matrix. This occurrence seems to be exceptional.

Andrews (36, p. 26) believed that the dips of the breccia, averaging about 35° but often reaching 50° or more, were largely initial. The writer does not concur in this, because Monterey shales and sandstones overlie the breccias in many places with no difference in strike or dip, and sediments of this nature could not be deposited with such a high initial dip. The present dip is evidently due to tilting long after the breccias were deposited.

Vent Tuff

Andrews (36, p. 24) recognized at least five vents in the Pinnacles area, characterized by "more or less circular masses of volcanic tuff within non-fragmental rhyolite." Another area of tuff marking a possible vent occurs half a mile east of Willow Creek Peak. This is a roughly oval-shaped area, a quarter of a mile in diameter, of decomposed white ash and lapilli-tuff, surrounded by and cut in a few places by rhyolite. The tuff on the periphery dips toward the center of the vent. The tuff is highly altered, sericitized and opalized, in places stained by hematite, indicating fumarolic action.

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[6] Williams, Howel, personal communication, 1940.

Several thin-sections of tuff and tuff-breccia from the Willow Creek Peak vent were examined. These contain angular lithic rhyolitic fragments in a fine-grained tuffaceous matrix. The lithic fragments are yellowish in color, and have been highly altered to a mixture of opal and sericite. They are largely glassy, partially devitrified, showing an occasional ''salt and pepper'' structure as well as microspherulites. The matrix of the tuff-breccia consists of irregular fragments of very fine-grained quartz and untwinned feldspar and partially devitrified glass. Microspherulitic structures occur in the matrix, often arranged along fractures. The microspherulites are 0.05 to 0.1 mm in diameter, have a refractive index below Canada balsam, and exhibit a uniaxial negative cross under crossed nicols.

The vent tuff is easily eroded and forms a low bench or basin-like area on the flank of Willow Creek Peak. The more resistant rhyolite surrounding the tuff forms a rim around part of the basin. The tuff is covered by a dense growth of chaparral (chamise and manzanita).

Age of the Volcanic Activity

The age of the Pinnacles formation and related volcanics has not been definitely determined, although there is little doubt that it is Miocene. The volcanics are overlain by a series of sediments correlated, largely on the basis of diatoms, with the Monterey group (upper Miocene). The volcanics are no younger than upper Miocene, therefore. However, the basal shale overlying the Pinnacles formation on Willow Creek may be of Temblor (middle Miocene) age, so that the volcanics could be middle Miocene or older.

There is no certain way of obtaining a lower limit of age of the volcanics, since they rest directly on granite. An indirect line of evidence is the occurrence of volcanics on the north flank of the Gabilan Range 30 miles northwest of the Pinnacles in the San Juan Bautista quadrangle. These are described by Kerr and Schenck (25, p. 473) as consisting of rhyolite, andesite, basalt, and agglomerate, and they overlie the Vaqueros sandstone (lower Miocene). If these volcanics are equivalent to those of the Pinnacles region, it would place a lower limit of Vaqueros as the age of the Pinnacles volcanics.

Herold (37) believes that the volcanic activity at the Pinnacles continued into the latest Miocene and possibly earliest Pliocene, on the basis of vitric tuffs found in the Salinas and Jamesburg quadrangles, whose source he thinks was in the Pinnacles area. Although a late Miocene age for some of the activity might be possible, it does not seem probable to the writer, and the great thickness of Miocene sediments overlying the volcanics would seem to exclude the possibility of a Pliocene age.

We may conclude that the Pinnacles volcanic activity is of Miocene age, most likely middle Miocene.

Basic Volcanics in Diablo Range

Three small, isolated areas of basic volcanics, chiefly basalt, occur in the Diablo Range in the San Benito quadrangle. These cannot be correlated with the volcanic activity at the Pinnacles. The occurrences are located: (1) half a mile south of Pine Rock, west of San Benito River, in the Santa Margarita formation; (2) on the east bank of Salt Creek, near center of Butts Ranch syncline, in the Temblor shale; and (3) on Chemise Ridge, north flank of Call Mountains, in the Paynes shale and sandstone member of the Panoche group.

The last two occurrences are probably intrusive, hence of uncertain age; but the first is a flow intercalated with the sediments of the Santa Margarita formation, and thus is upper Miocene. This Santa Margarita flow has a maximum thickness of 200 feet, and is exposed for nearly three-quarters of a mile. The lower contact with the Santa Margarita sediments is well exposed in one place; here a fine-grained white sandstone is baked and colored reddish for a distance of 1 to 2 feet below the contact. The basalt is black, or greenish on fresh surface, and forms a reddish soil. It is amygdaloidal, the amygdules being calcite. The rock is also cut by small veinlets of calcite.

Examined microscopically, the basalt in the Santa Margarita formation is seen to be porphyritic, with an intersertal groundmass. The phenocrysts are of labradorite ($Ab_{40}An_{60}$) and occasional titaniferous augite. The groundmass consists of lath-shaped plagioclase, augite, magnetite, and occasional iddingsite derived from olivine. The feldspars show both albite and Carlsbad twinning, and often have a latticework of magnetite inclusions.

Monterey Group (Upper Miocene)

The Monterey group (Blake 56, pp. 328-331) is represented by a fairly thin basal shale member, overlain by a considerable thickness of arkosic sandstone and conglomerate, which is interbedded toward the top with diatomaceous shale. An interesting feature is the gradation of the marine diatomaceous shale into very coarse conglomerate, probably non-marine, toward the west. There is good evidence of a western shoreline of the Monterey sea in the Gabilan Range.

The Monterey group is confined to the Gabilan Range, southwest of the Bear Valley fault. The basal shale rests depositionally (either conformably or disconformably) upon the Pinnacles formation along Willow Creek. The arkose rests unconformably upon the Pinnacles formation and Miocene rhyolite in the southern part of the quadrangle, and upon granite in the northwestern part of the area.

The basal shale forms a belt of low, well-rounded grass-covered slopes, supporting scattered oak trees. The arkosic sandstone and conglomerate is moderately resistant to erosion, and supports a moderate to dense growth of sagebrush or chaparral (chamise and manzanita). The diatomaceous shale is slightly less resistant and supports less dense vegetation of the same type as the arkose.

Basal Shale

The basal shale of the Monterey group consists of platy calcareous and siliceous shale, interbedded with softer clay-shale. It is well bedded in layers 1 to 3 inches thick. The shale weathers white but is chocolate brown upon fresh exposure. Some of it is banded and cherty. A few beds 1 or 2 feet thick of fine-grained well-cemented arkosic sandstone are interbedded with the shale in places. The member has a thickness of 450 to 1100 feet.

Arkosic Sandstone and Conglomerate

The greatest part of the Monterey group consists of arkosic sandstone and conglomerate, with a total thickness of 1500 to 3000 feet. The material shows rapid lateral and vertical variation. In general it is very poorly sorted, containing in a sandy matrix pebbles and boulders averaging a few inches but ranging up to 12 feet in diameter. The sand grains are chiefly angular, in part subangular, and only the larger boulders are subrounded. The sandstone is highly arkosic, consisting chiefly of fresh feldspar (mainly orthoclase), quartz, and biotite; and a small percentage of heavy accessories, including muscovite, zircon, sphene, garnet, epidote, magnetite, augite, diopside, enstatite, and hypersthene. The pebbles and boulders consist entirely of granite and rhyolite. The granitic debris is generally dominant, but there are certain layers in which rhyolitic material is concentrated. Parts of the arkose are fairly well cemented by calcium carbonate, but most of the material is poorly consolidated.

The abundance of granite and rhyolite debris indicates derivation of material from part of the Gabilan Range, which was probably an island during the upper Miocene. The poor sorting, rapid lateral and vertical variation, angularity of grain, and extreme coarseness of some of the arkose suggest non-marine deposition, probably of the fanglomerate type. The deposits become finer grained and grade into marine deposits to the east, indicated by the diatomaceous shales and by the occurrence in at least one locality of marine molluscan fossils in the arkose.

Diatomaceous Shale

Diatomaceous shales are interbedded with the arkosic sandstone and conglomerate near the top of the section. These are well bedded, punky, and have a brilliant white appearance both on weathered surfaces and fresh exposures. Under the microscope, diatoms are seen to be very abundant. At least two or three different members of diatomaceous shale are present, ranging in thickness from 100 to 200 feet.

The most interesting feature of the diatomaceous shales is their interbedding with and gradation into coarse arkosic sandstone and conglomerate toward the west. At the head of the north branch of Chalone Creek the relations of the shale to the arkose are well exposed. At one place is a continuous section of 800 feet of diatomaceous shale with only a few intervening layers of fine-grained arkosic sandstone. Toward the west more and more sandstone of coarser grain-size interfingers with and grades into the shale. Layers of shale may be followed into sandstone along the strike. The last canyon in which the shale is exposed shows a series of several tens of layers of diatomaceous shale, 2 to 3 feet thick, separated by bands of sandstone and conglomerate, 15 to 20 feet thick, much of it very coarse. In the next well-exposed canyon, a quarter of a mile west of where the shale disappears, only poorly sorted sandstone and conglomerate is exposed, some of it containing boulders up to 12 feet in diameter. The relations described above are clearly shown on an aerial photograph.

This occurrence is of interest in that diatomaceous shales have often been thought to indicate comparatively clear, quiet water, with very little terrigenous material being supplied to the depositional basin. Such cannot have been the case in this instance.

Fossils, Correlation, and Age

Fossils are rare in the Monterey group in this area. Only one locality of megafossils was found, near the eastern end of the Bickmore Canyon road. Here a few molluscan molds and casts together with leaf imprints occur in a fine-grained, well-cemented, arkosic sandstone. The identifiable mollusks were determined by L. G. Hertlein as *Taras harfordi* (F. M. Anderson), which has a range from Temblor to Etchegoin. Other undetermined pelecypods and gastropods are present. The leaves were determined by Ralph W. Chaney as cf. *Quercus previrginiana* Berry and cf. *Persea pseudocarolinensis* Lesquereux. He states that both of these species occur in the Monterey flora west of Carmel.

Diatoms from the diatomaceous shales of this area were identified by Kerr and Schenck (25, p. 484) as *Coscinodiscus incretus* A. Schmidt. H. G. Schenck states that an abundance of diatoms of this type is characteristic of the Delmontian, uppermost stage of the Miocene.[7]

It is largely on the basis of the diatoms and lithologic nature of the shale that the diatomaceous shales and interbedded arkosic sediments are referred to the Monterey group. The leaves and mollusks are compatible with this correlation. The basal shale, on the other hand, apparently contains no diatoms or other fossils, and its correlation is largely a matter of conjecture. It could be Temblor as readily as Monterey, and in fact is lithologically similar to the Temblor shales west of the Salinas Valley and in the Butts Ranch syncline area. The conformable contact with the Monterey makes it seem improbable that the shale is any older than Temblor (middle Miocene).

Santa Margarita Formation (Upper Miocene)

The Santa Margarita formation (Fairbanks 04) consists mainly of fossiliferous grayish calcareous sandstone, containing ''reef'' beds and pebbly conglomeratic layers, and occasional interbedded clay-shales. It has a maximum thickness of more than 2000 feet. It is exposed only in a narrow belt along the southwest bank of the San Benito River in the southern part of the quadrangle. The northernmost exposure is along the great bend of the San Benito River just west of the mouth of Sulphur Creek. This narrow belt dips uniformly to the west below the basal red beds of the overlying Etchegoin group. On the east the Santa Margarita is in fault contact with the Etchegoin along the Pine Rock fault, and the base is nowhere exposed. However, in a continuation of this belt to the southeast in the Priest Valley quadrangle, the Santa Margarita rests unconformably upon the Franciscan, according to Mielenz (39, p. 174).

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[7] Personal communication, 1941.

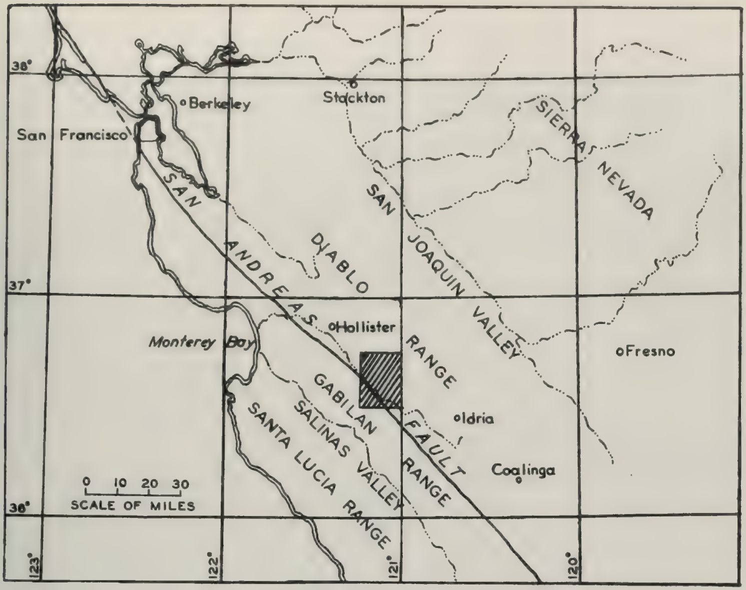

38°
37°
36°
123°
122°
121°
120°
Berkeley
Stockton
San Francisco
SIERRA NEVADA
SAN JOAQUIN VALLEY
SAN ANDREAS FAULT
DIABLO RANGE
Hollister
Monterey Bay
Fresno
GABILAN RANGE
SALINAS VALLEY
SANTA LUCIA RANGE
Idria
Coalinga
0 10 20 30
SCALE OF MILES

FIG. 1. Index map showing location of the San Benito quadrangle.

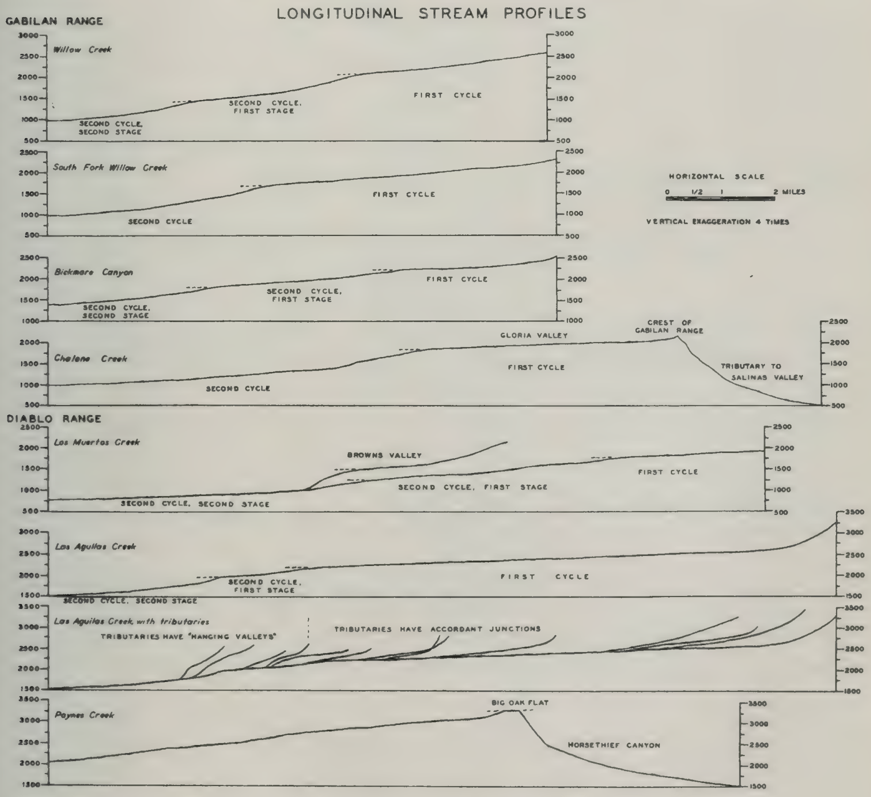
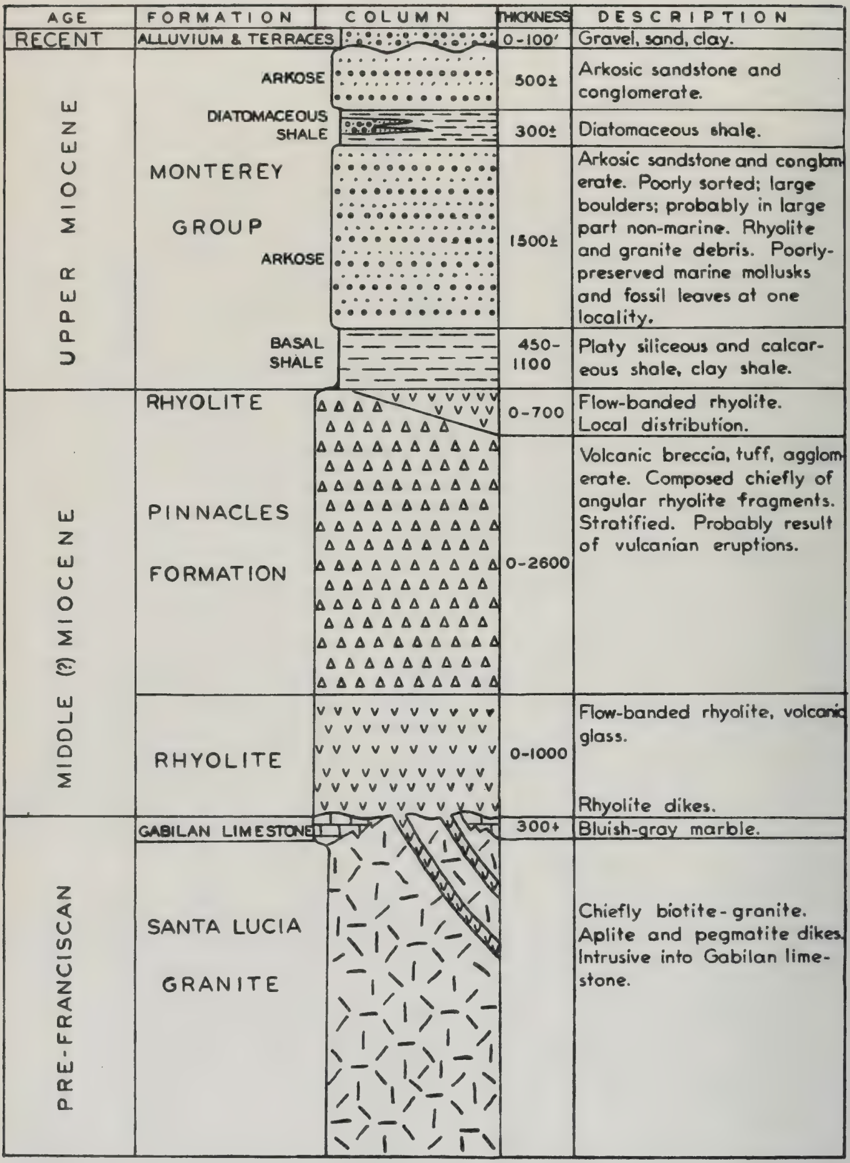
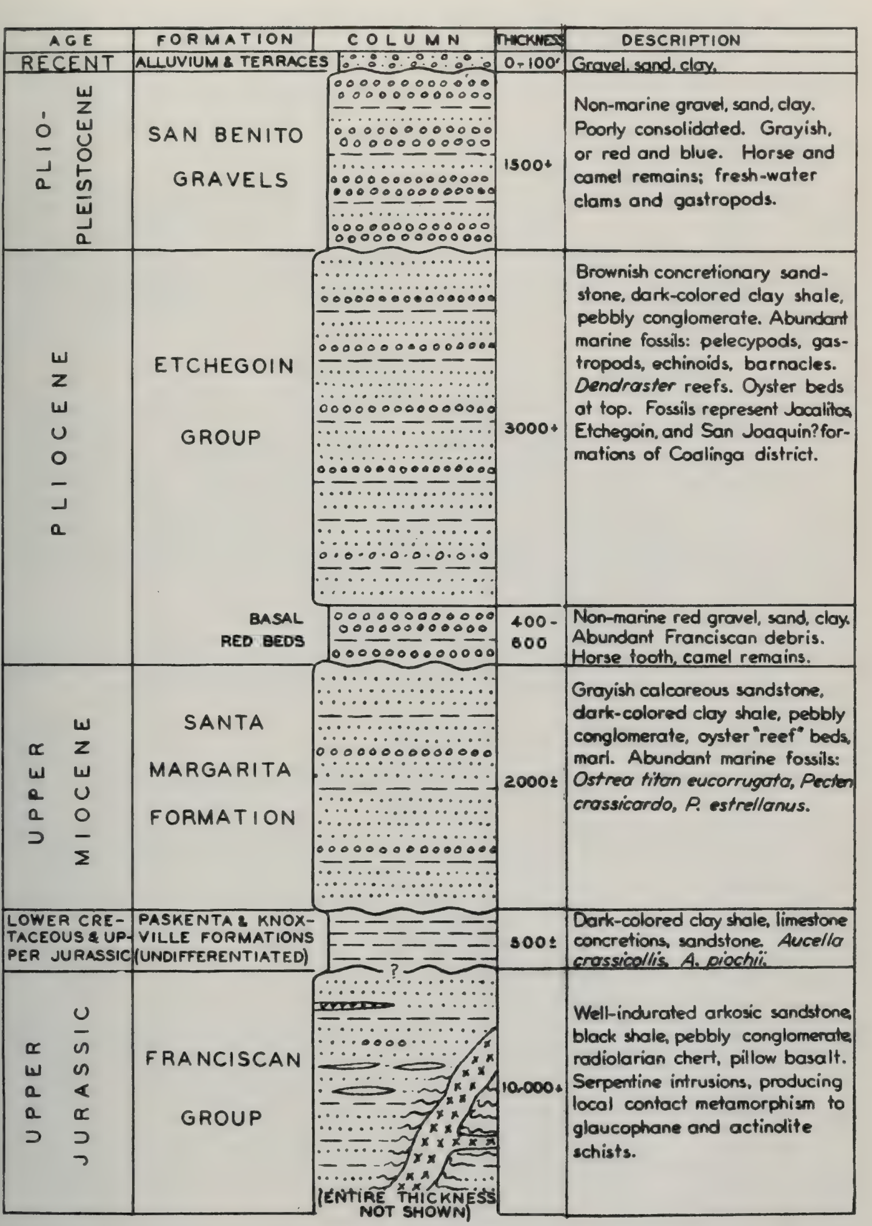

LONGITUDINAL STREAM PROFILES

FIG. 2. Longitudinal stream profiles, showing two cycles of erosion.



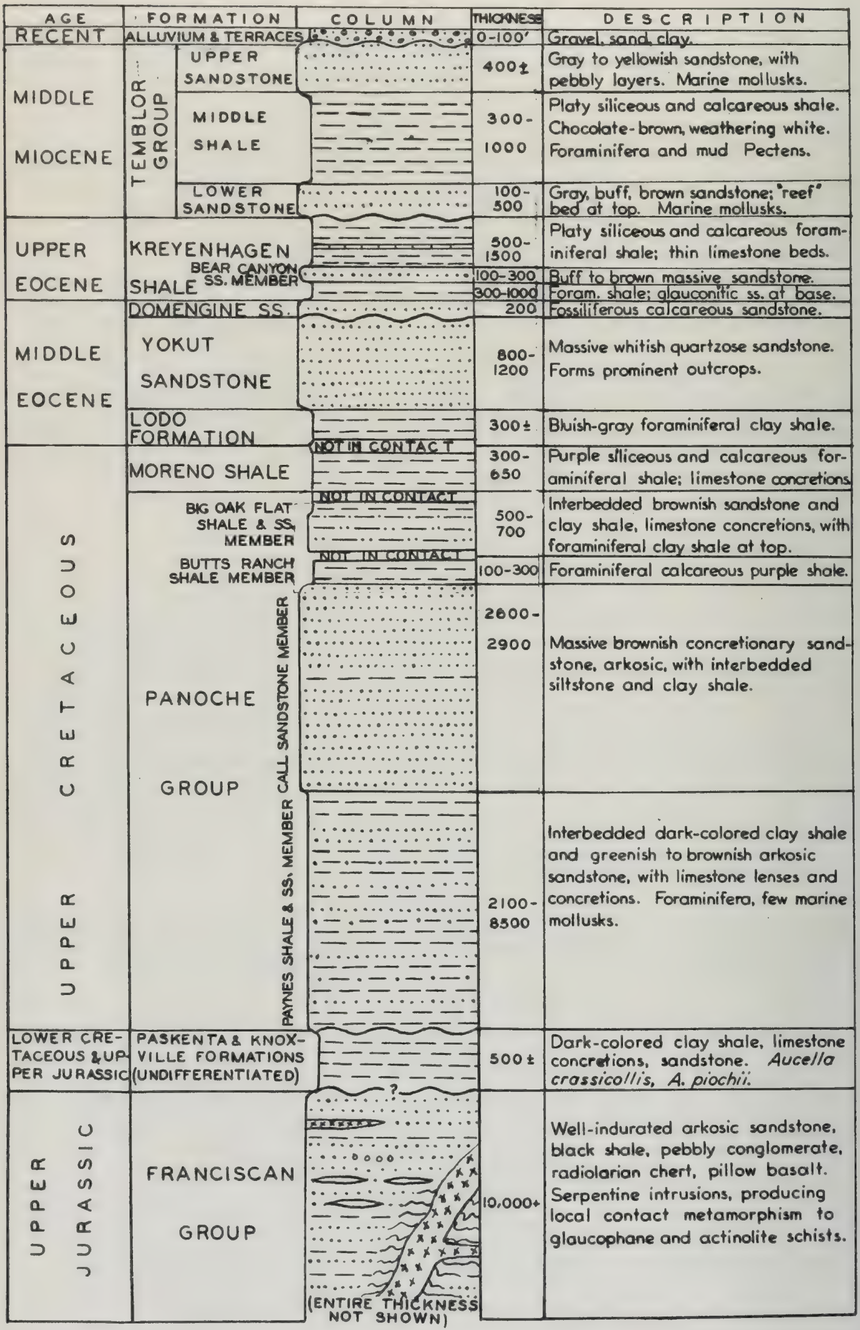
AGE	FORMATION	COLUMN	THICKNESS	DESCRIPTION
RECENT	ALLUVIUM & TERRACES		0-100′	Gravel, sand, clay.
UPPER MIOCENE	MONTEREY GROUP ARKOSE		500±	Arkosic sandstone and conglomerate.
	DIATOMACEOUS SHALE		300±	Diatomaceous shale.
	ARKOSE		1500±	Arkosic sandstone and conglomerate. Poorly sorted; large boulders; probably in large part non-marine. Rhyolite and granite debris. Poorly-preserved marine mollusks and fossil leaves at one locality.
	BASAL SHALE		450-1100	Platy siliceous and calcareous shale, clay shale.
MIDDLE (?) MIOCENE	RHYOLITE		0-700	Flow-banded rhyolite. Local distribution.
	PINNACLES FORMATION		0-2600	Volcanic breccia, tuff, agglomerate. Composed chiefly of angular rhyolite fragments. Stratified. Probably result of vulcanian eruptions.
	RHYOLITE		0-1000	Flow-banded rhyolite, volcanic glass. Rhyolite dikes.
PRE-FRANCISCAN	GABILAN LIMESTONE		300+	Bluish-gray marble.
	SANTA LUCIA GRANITE			Chiefly biotite-granite. Aplite and pegmatite dikes. Intrusive into Gabilan limestone.

FIG. 3. Stratigraphic column, Gabilan Range, San Benito quadrangle.



AGE	FORMATION	COLUMN	THICKNESS	DESCRIPTION
RECENT	ALLUVIUM & TERRACES		0-100′	Gravel, sand, clay.
PLIO-PLEISTOCENE	SAN BENITO GRAVELS		1500+	Non-marine gravel, sand, clay. Poorly consolidated. Grayish, or red and blue. Horse and camel remains; fresh-water clams and gastropods.
PLIOCENE	ETCHEGOIN GROUP		3000+	Brownish concretionary sandstone, dark-colored clay shale, pebbly conglomerate. Abundant marine fossils: pelecypods, gastropods, echinoids, barnacles. *Dendraster* reefs. Oyster beds at top. Fossils represent Jacalitos, Etchegoin, and San Joaquin? formations of Coalinga district.
	BASAL RED BEDS		400-600	Non-marine red gravel, sand, clay. Abundant Franciscan debris. Horse tooth, camel remains.
UPPER MIOCENE	SANTA MARGARITA FORMATION		2000±	Grayish calcareous sandstone, dark-colored clay shale, pebbly conglomerate, oyster "reef" beds, marl. Abundant marine fossils: *Ostrea titan eucorrugata, Pecten crassicardo, P. estrellanus.*
LOWER CRETACEOUS & UPPER JURASSIC	PASKENTA & KNOXVILLE FORMATIONS (UNDIFFERENTIATED)	?	500±	Dark-colored clay shale, limestone concretions, sandstone. *Aucella crassicollis, A. piochii.*
UPPER JURASSIC	FRANCISCAN GROUP	(ENTIRE THICKNESS NOT SHOWN)	10,000+	Well-indurated arkosic sandstone, black shale, pebbly conglomerate, radiolarian chert, pillow basalt. Serpentine intrusions, producing local contact metamorphism to glaucophane and actinolite schists.

FIG. 4. Stratigraphic column, San Benito River area, San Benito quadrangle.



AGE	FORMATION		COLUMN	THICKNESS	DESCRIPTION
RECENT	ALLUVIUM & TERRACES			0-100′	Gravel, sand, clay.
MIDDLE MIOCENE	TEMBLOR GROUP	UPPER SANDSTONE		400±	Gray to yellowish sandstone, with pebbly layers. Marine mollusks.
		MIDDLE SHALE		300-1000	Platy siliceous and calcareous shale. Chocolate-brown, weathering white. Foraminifera and mud Pectens.
		LOWER SANDSTONE		100-500	Gray, buff, brown sandstone; "reef" bed at top. Marine mollusks.
UPPER EOCENE	KREYENHAGEN SHALE			500-1500	Platy siliceous and calcareous foraminiferal shale; thin limestone beds.
		BEAR CANYON SS. MEMBER		100-300	Buff to brown massive sandstone.
				300-1000	Foram. shale; glauconitic ss. at base.
	DOMENGINE SS.			200	Fossiliferous calcareous sandstone.
MIDDLE EOCENE	YOKUT SANDSTONE			800-1200	Massive whitish quartzose sandstone. Forms prominent outcrops.
	LODO FORMATION			300±	Bluish-gray foraminiferal clay shale.
UPPER CRETACEOUS	MORENO SHALE		NOT IN CONTACT	300-650	Purple siliceous and calcareous foraminiferal shale; limestone concretions.
	PANOCHE GROUP	BIG OAK FLAT SHALE & SS. MEMBER	NOT IN CONTACT	500-700	Interbedded brownish sandstone and clay shale, limestone concretions, with foraminiferal clay shale at top.
		BUTTS RANCH SHALE MEMBER	NOT IN CONTACT	100-300	Foraminiferal calcareous purple shale.
		CALL SANDSTONE MEMBER		2600-2900	Massive brownish concretionary sandstone, arkosic, with interbedded siltstone and clay shale.
		PAYNES SHALE & SS. MEMBER		2100-8500	Interbedded dark-colored clay shale and greenish to brownish arkosic sandstone, with limestone lenses and concretions. Foraminifera, few marine mollusks.
LOWER CRETACEOUS & UPPER JURASSIC	PASKENTA & KNOXVILLE FORMATIONS (UNDIFFERENTIATED)			500±	Dark-colored clay shale, limestone concretions, sandstone. *Aucella crassicollis, A. piochii.*
UPPER JURASSIC	FRANCISCAN GROUP		? (ENTIRE THICKNESS NOT SHOWN)	10,000+	Well-indurated arkosic sandstone, black shale, pebbly conglomerate, radiolarian chert, pillow basalt. Serpentine intrusions, producing local contact metamorphism to glaucophane and actinolite schists.

FIG. 5. Stratigraphic column, Butts Ranch syncline, San Benito quadrangle.

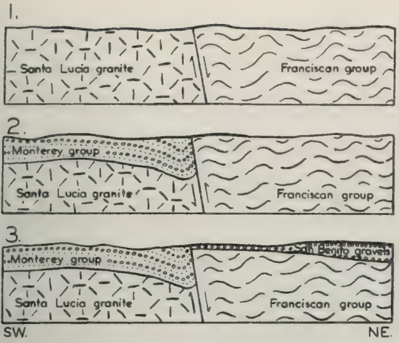

1.
Santa Lucia granite
Franciscan group
2.
Monterey group
Santa Lucia granite
Franciscan group
3.
Monterey group
San Benito gravels
Santa Lucia granite
Franciscan group
SW.
NE.

FIG. 6. Successive movements on the Bear Valley fault. 1. Pre-Miocene (probably Eocene): Franciscan upthrown and eroded off granite on southwest side. 2. Between upper Miocene and Pleistocene (probably upper Pliocene): Franciscan on northeast side thrust over Monterey. 3. Late Pleistocene or Recent: San Benito gravels downthrown on northeast side.

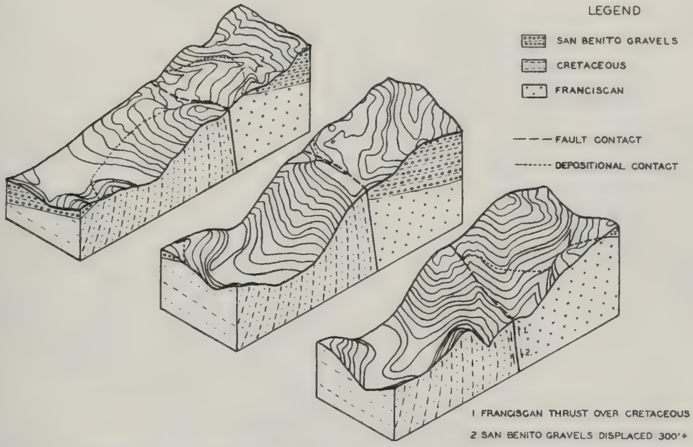

LEGEND
SAN BENITO GRAVELS
CRETACEOUS
FRANCISCAN
FAULT CONTACT
DEPOSITIONAL CONTACT
1
2
1 FRANCISCAN THRUST OVER CRETACEOUS
2 SAN BENITO GRAVELS DISPLACED 300'+

FIG. 7. Block diagrams showing reversal of movement along the Bradford fault.

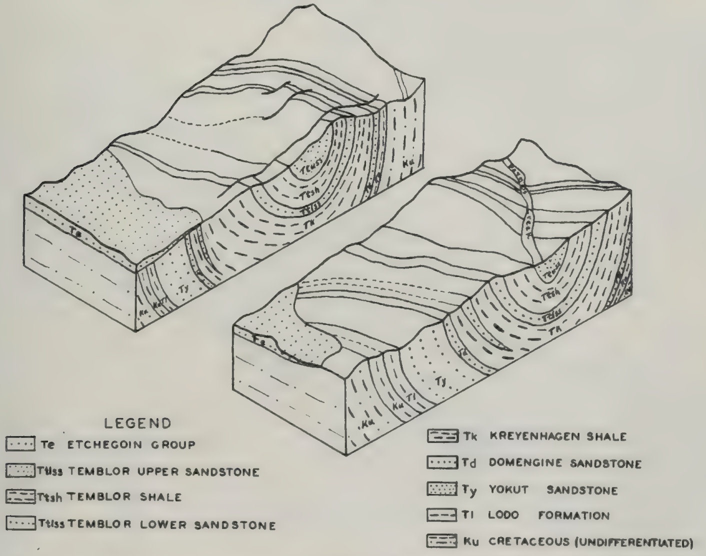

Te
Ttuss
Ttsh
Ttlss
Tk
Ku
Ty
LEGEND
Te ETCHEGOIN GROUP
Ttuss TEMBLOR UPPER SANDSTONE
Ttsh TEMBLOR SHALE
Ttlss TEMBLOR LOWER SANDSTONE
Tk KREYENHAGEN SHALE
Td DOMENGINE SANDSTONE
Ty YOKUT SANDSTONE
Tl LODO FORMATION
Ku CRETACEOUS (UNDIFFERENTIATED)

FIG. 8. Block diagrams showing overlap of Etchegoin sediments onto the Butts Ranch syncline.

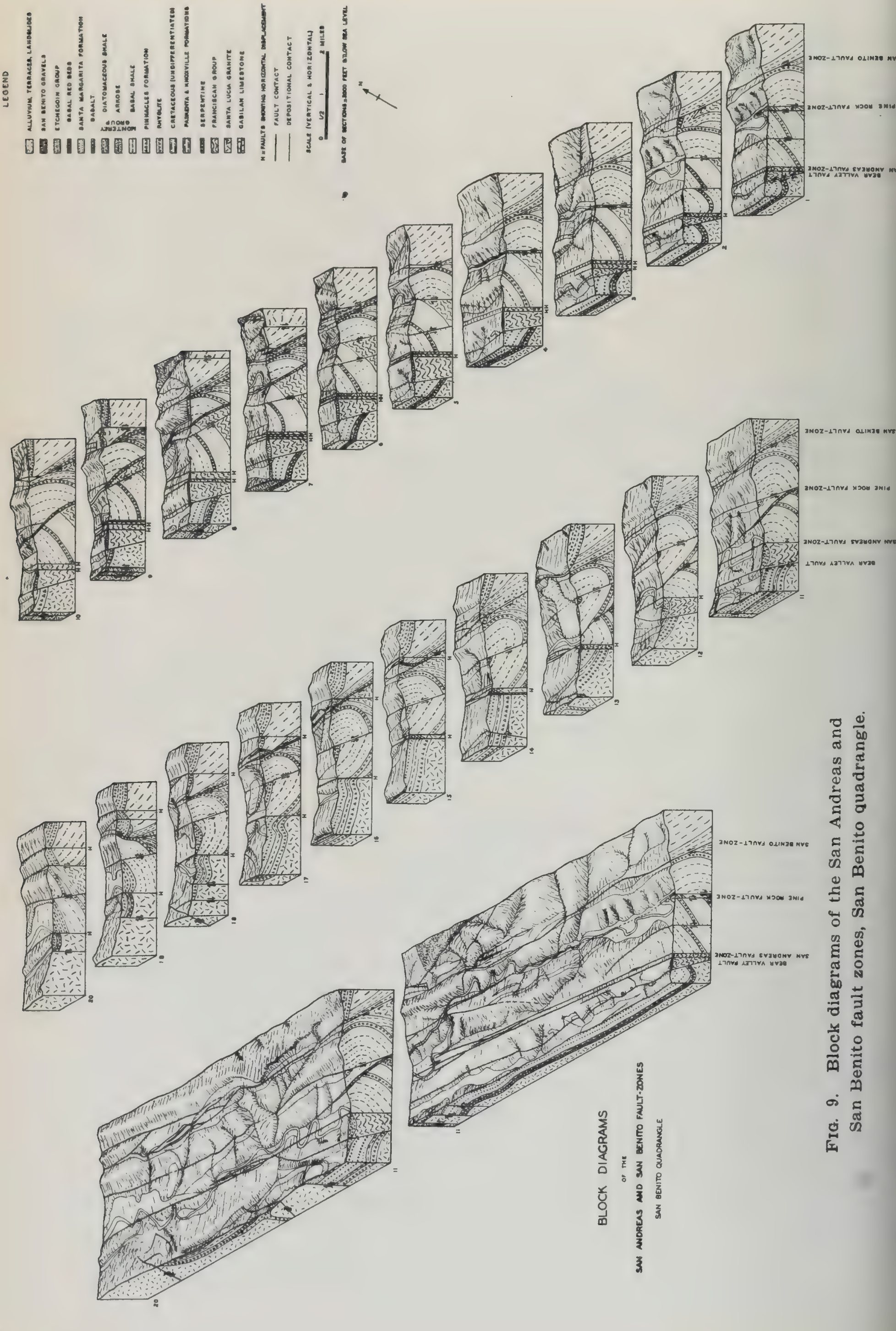

LEGEND
ALLUVIUM, TERRACES, LANDSLIDES
SAN BENITO GRAVELS
ETCHEGOIN GROUP
BASAL RED BEDS
SANTA MARGARITA FORMATION
BASALT
MONTEREY GROUP
DIATOMACEOUS SHALE
ARKOSE
BASAL SHALE
PINNACLES FORMATION
RHYOLITE
CRETACEOUS (UNDIFFERENTIATED)
PANOCHE & KNOXVILLE FORMATIONS
SERPENTINE
FRANCISCAN GROUP
SANTA LUCIA GRANITE
GABILAN LIMESTONE
H = FAULTS SHOWING HORIZONTAL DISPLACEMENT
FAULT CONTACT
DEPOSITIONAL CONTACT
SCALE (VERTICAL & HORIZONTAL)
0
1/2
1
2 MILES
BASE OF SECTIONS = 2000 FEET BELOW SEA LEVEL
N
SAN BENITO FAULT-ZONE
PINE ROCK FAULT-ZONE
SAN ANDREAS FAULT-ZONE
BEAR VALLEY FAULT
BLOCK DIAGRAMS
OF THE
SAN ANDREAS AND SAN BENITO FAULT-ZONES
SAN BENITO QUADRANGLE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

FIG. 9. Block diagrams of the San Andreas and San Benito fault zones, San Benito quadrangle.

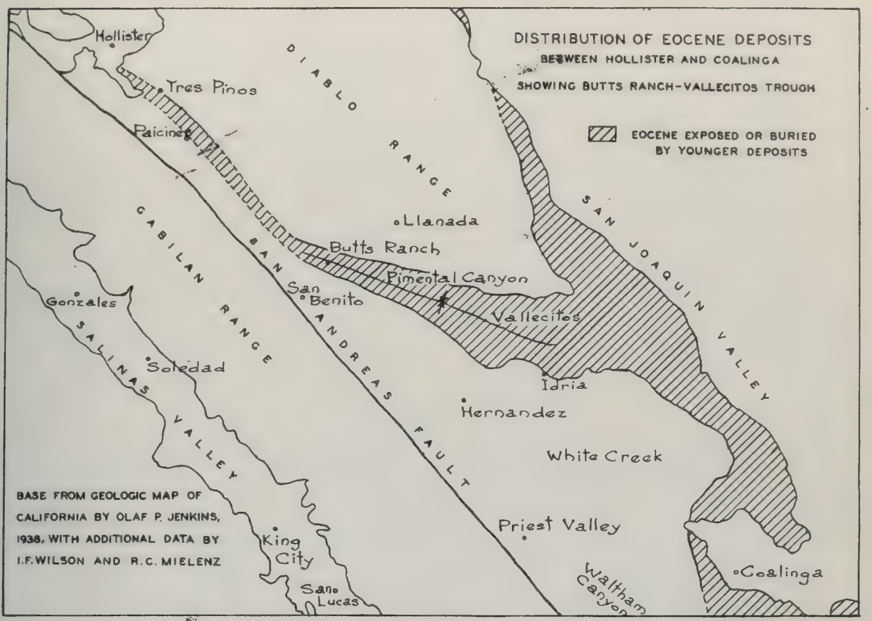

DISTRIBUTION OF EOCENE DEPOSITS
BETWEEN HOLLISTER AND COALINGA
SHOWING BUTTS RANCH-VALLECITOS TROUGH
▨ EOCENE EXPOSED OR BURIED BY YOUNGER DEPOSITS
Hollister
Tres Pinos
Paicines
DIABLO RANGE
Llanada
Butts Ranch
Pimental Canyon
Vallecitos
San Benito
SAN JOAQUIN VALLEY
GABILAN RANGE
SAN ANDREAS FAULT
Gonzales
SALINAS VALLEY
Soledad
Idria
Hernandez
White Creek
Priest Valley
King City
San Lucas
Waltham Canyon
Coalinga
BASE FROM GEOLOGIC MAP OF CALIFORNIA BY OLAF P. JENKINS, 1938, WITH ADDITIONAL DATA BY I.F. WILSON AND R.C. MIELENZ

FIG. 10. Distribution of Eocene deposits between Hollister and Coalinga, showing Butts Ranch—Vallecitos trough.

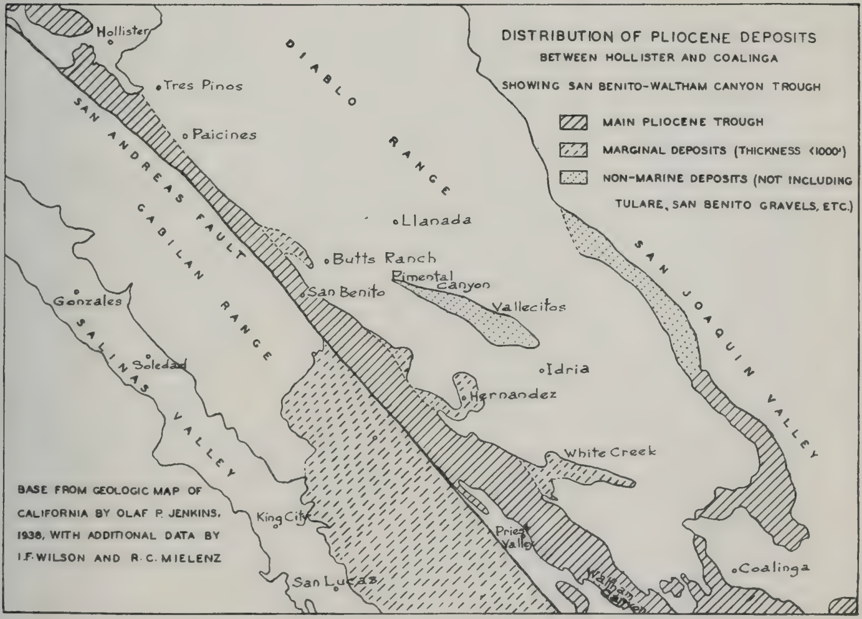
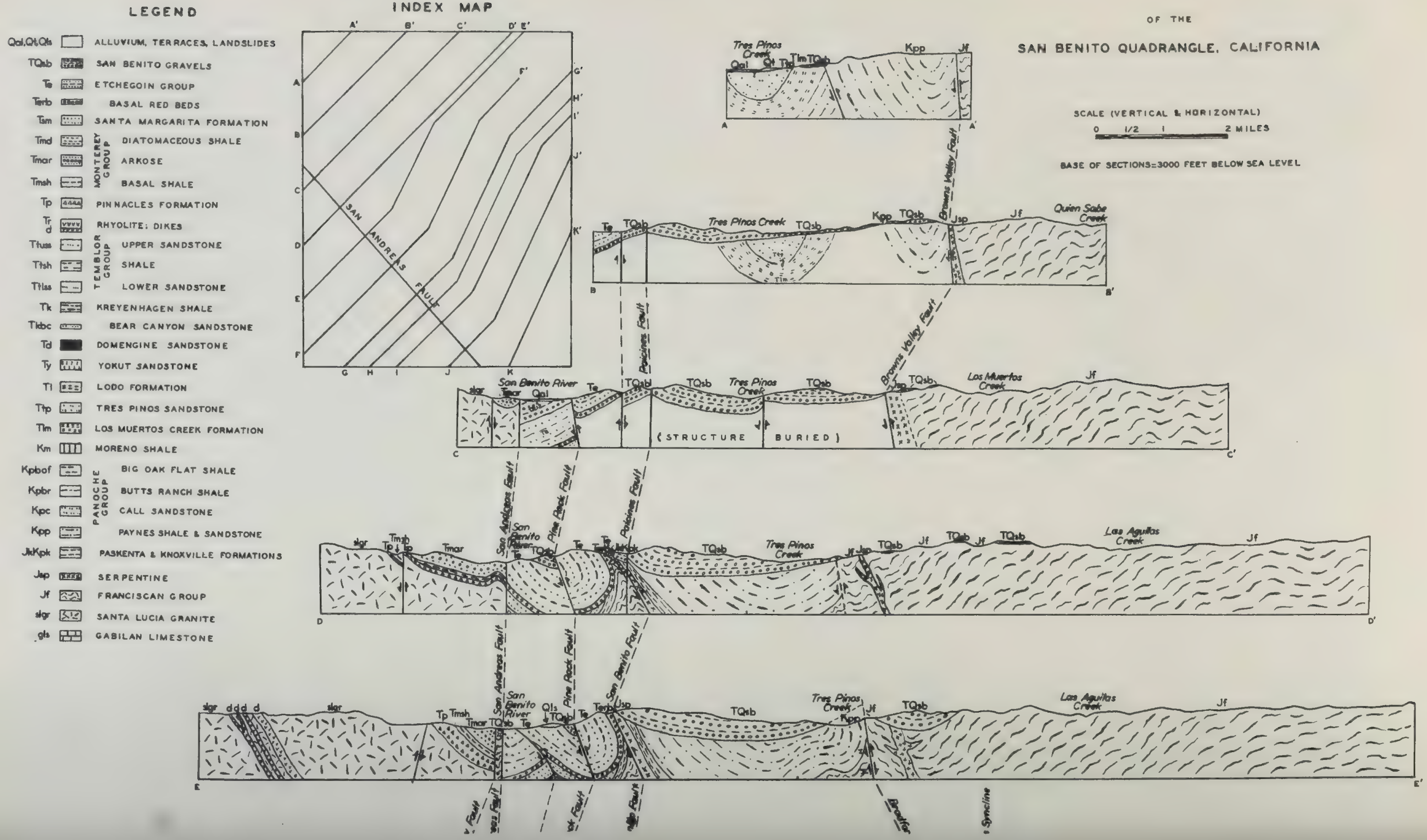

DISTRIBUTION OF PLIOCENE DEPOSITS
BETWEEN HOLLISTER AND COALINGA
SHOWING SAN BENITO-WALTHAM CANYON TROUGH
▨ MAIN PLIOCENE TROUGH
▨ MARGINAL DEPOSITS (THICKNESS <1000')
▨ NON-MARINE DEPOSITS (NOT INCLUDING TULARE, SAN BENITO GRAVELS, ETC.)
Hollister
Tres Pinos
Paicines
DIABLO RANGE
SAN ANDREAS FAULT
GABILAN RANGE
Llanada
Butts Ranch
Pimental Canyon
Vallecitos
San Benito
Gonzales
SALINAS VALLEY
Soledad
Idria
Hernandez
SAN JOAQUIN VALLEY
White Creek
King City
Priest Valley
San Lucas
Waltham Canyon
Coalinga
BASE FROM GEOLOGIC MAP OF CALIFORNIA BY OLAF P. JENKINS, 1938, WITH ADDITIONAL DATA BY I.F. WILSON AND R.C. MIELENZ

FIG. 11. Distribution of Pliocene deposits between Hollister and Coalinga, showing San Benito—Waltham Canyon trough.

GEOLOGIC STRUCTURE SECTIONS

OF THE

SAN BENITO QUADRANGLE, CALIFORNIA


LEGEND
Qal,Qt,Qls ALLUVIUM, TERRACES, LANDSLIDES
TQsb SAN BENITO GRAVELS
Te ETCHEGOIN GROUP
Terb BASAL RED BEDS
Tsm SANTA MARGARITA FORMATION
MONTEREY GROUP
Tmd DIATOMACEOUS SHALE
Tmar ARKOSE
Tmsh BASAL SHALE
Tp PINNACLES FORMATION
Tr d RHYOLITE; DIKES
TEMBLOR GROUP
Ttus UPPER SANDSTONE
Ttsh SHALE
Ttls LOWER SANDSTONE
Tk KREYENHAGEN SHALE
Tkbc BEAR CANYON SANDSTONE
Td DOMENGINE SANDSTONE
Ty YOKUT SANDSTONE
Tl LODO FORMATION
Ttp TRES PINOS SANDSTONE
Tlm LOS MUERTOS CREEK FORMATION
Km MORENO SHALE
PANOCHE GROUP
Kpbof BIG OAK FLAT SHALE
Kpbr BUTTS RANCH SHALE
Kpc CALL SANDSTONE
Kpp PAYNES SHALE & SANDSTONE
JkKpk PASKENTA & KNOXVILLE FORMATIONS
Jsp SERPENTINE
Jf FRANCISCAN GROUP
slgr SANTA LUCIA GRANITE
gls GABILAN LIMESTONE
INDEX MAP
A' B' C' D' E'
F' G' H' I' J' K'
A B C D E F
G H I J K
SAN ANDREAS FAULT
SCALE (VERTICAL & HORIZONTAL)
0 1/2 1 2 MILES
BASE OF SECTIONS=3000 FEET BELOW SEA LEVEL
A A'
Tres Pinos Creek
Qal Qt Ttp Tlm TQsb Kpp Jf
B B'
Te TQsb Tres Pinos Creek Kpp Jsp Jf Quien Sabe Creek
Browns Valley Fault
Paicines Fault
C C'
slgr San Benito River Tmar Qal Te TQsb Tres Pinos Creek Los Muertos Creek Jf
(STRUCTURE BURIED)
San Andreas Fault
Pine Rock Fault
D D'
slgr Tp Tmsh Tmar San Benito River Te TQsb Tres Pinos Creek Jsp Jf Las Aguilas Creek
E E'
slgr d d d d Tp Tmsh Tmar San Benito River Qls Te Terb Jsp TQsb Tres Pinos Creek Kpp Jf Las Aguilas Creek
San Benito Fault
Bradfor
Syncline

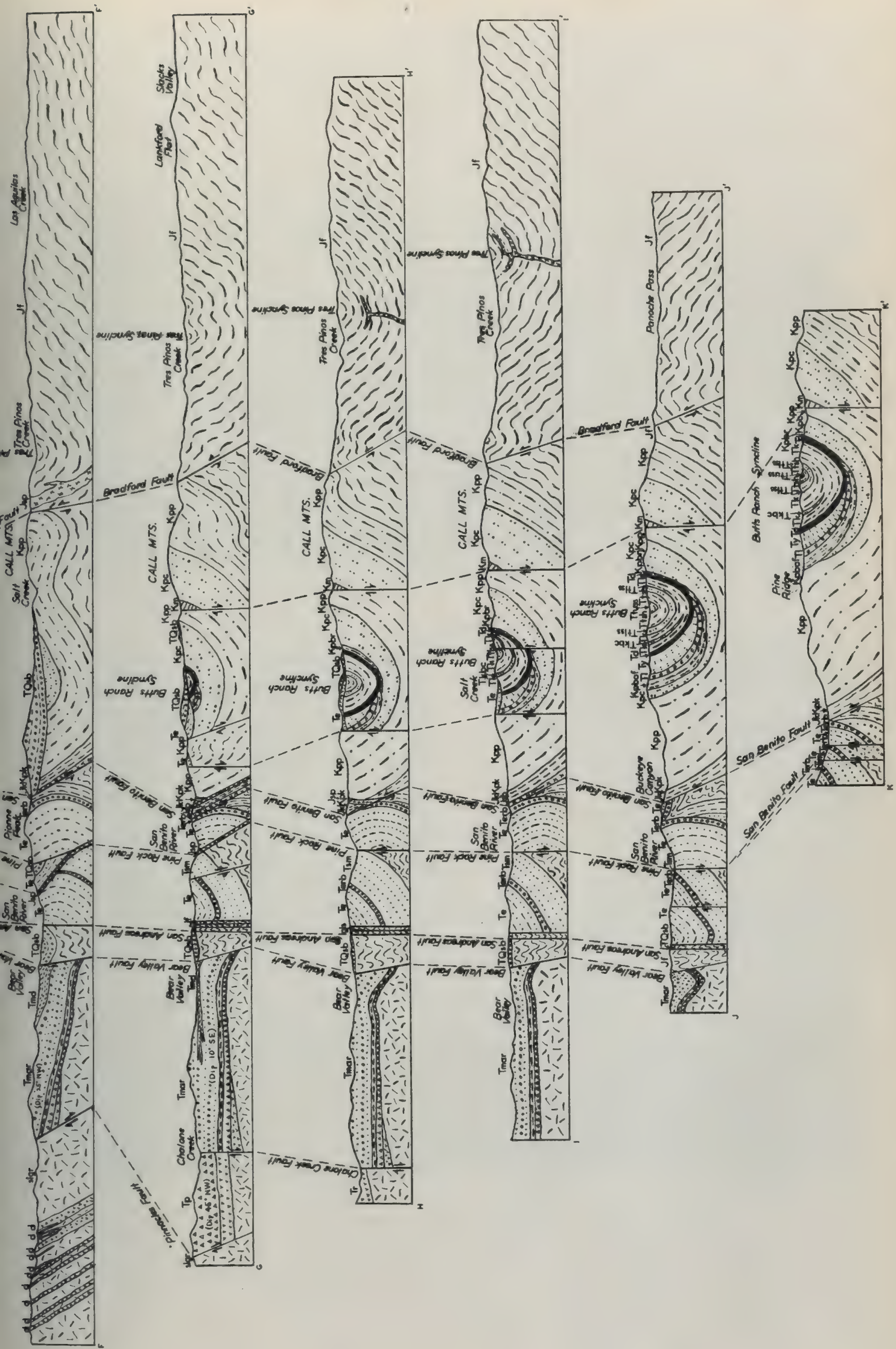

F
F'
G
G'
H
H'
I
I'
J
J'
K
K'
Los Aguilas Creek
Stacks Valley
Lankford Flat
Tres Pinos Creek
Tres Pinos Syncline
Panoche Pass
Bradford Fault
CALL MTS.
Salt Creek
Butts Ranch Syncline
Pine Ridge
San Benito Fault
Buckeye Canyon
San Benito River
Pine Rock Fault
San Andreas Fault
Bear Valley Fault
Bear Valley
Chalone Creek
Chalone Creek Fault
Pinnacles Fault
Jf
Kpp
Kpc
Km
TQsb
Te
Tmar
Tmd
Tp
sgr
d
(Dip 35° NW)
(Dip 10° SE)
(Dip 40° NW)

FIG. 12. Geologic structure sections of the San Benito quadrangle, California.

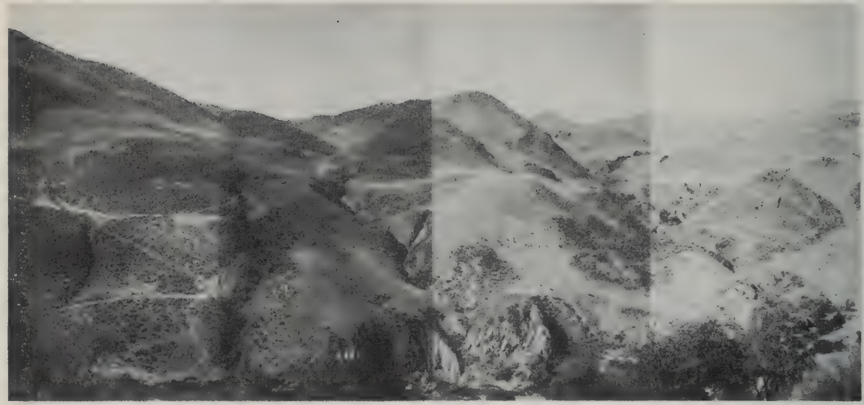


FIG. 13. Typical Franciscan terrain, showing characteristic irregular "knobby" topography. Chiefly sandstone and shale, with some basalt. Panoche covered with sagebrush on the far left. North side of Los Muertos Creek.

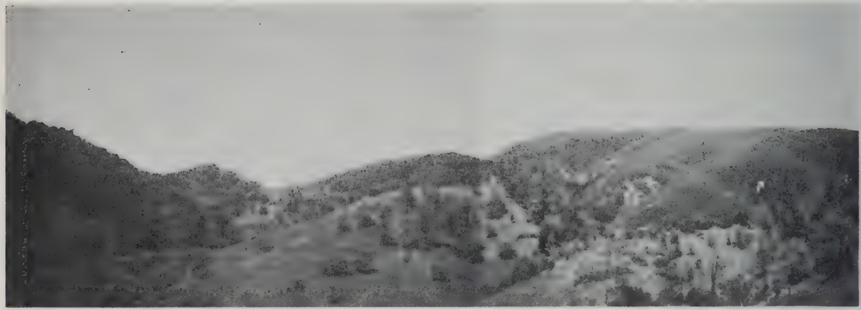


FIG. 14. Grass-covered belt of Moreno shale, bordered on the right by brush-covered Call sandstone member of Panoche group. View west from Paynes Creek.

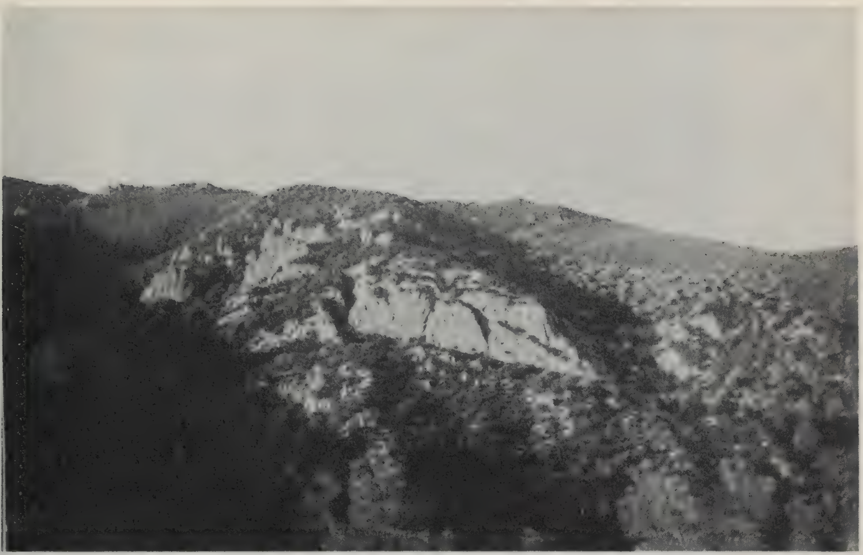


FIG. 15. Prominent outcrops of Call sandstone member of Panoche group, steeply dipping toward the observer. Call Mountains, looking north between Paynes Creek and Bitterwater Creek.

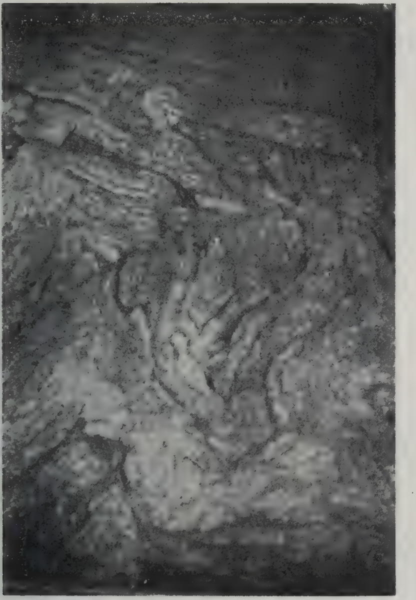


FIG. 16. Highly contorted Monterey shale adjacent to a transverse fault. Road cut, half a mile northwest of head of Bear Valley.

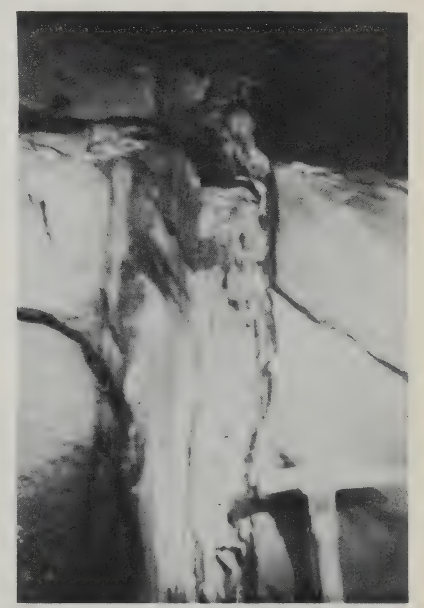


FIG. 17. Graded bedding in Call sandstone member of Panoche group. Shows gradation (from left to right) from sandstone through siltstone to clay-shale, followed by an abrupt change to sandstone. Top side of beds is to right. East bank of Paynes Creek.

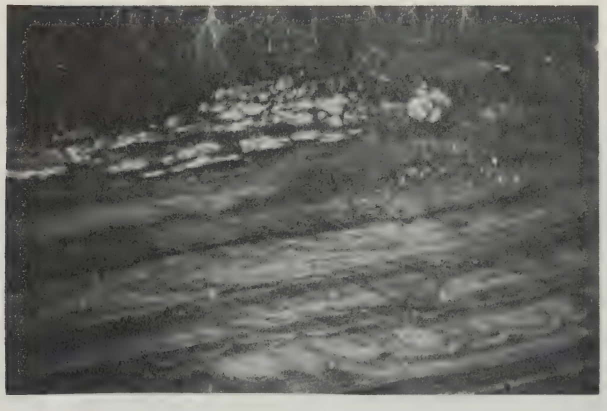


FIG. 18. Intraformational contortion in siltstone, Call sandstone member of Panoche group. West bank of Moody Gulch, Panoche quadrangle.

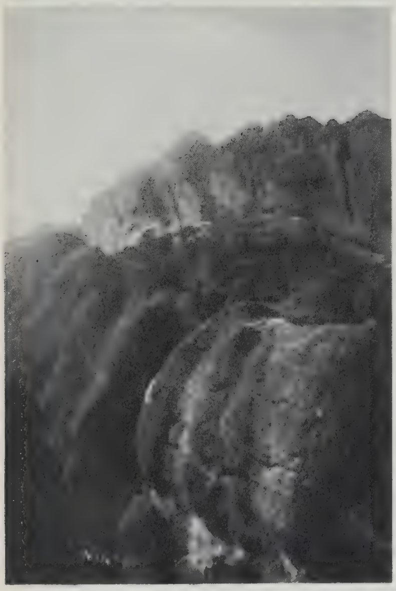


FIG. 19. Pinnacles formation, dipping north, forming "The Balcony," north end of Pinnacles National Monument.

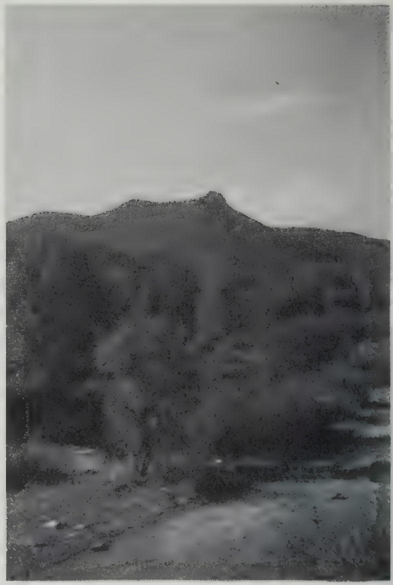


FIG. 20. Willow Creek Peak, formed of steeply dipping rhyolite flows, bordered by an area of vent tuff in the foreground. View west from Willow Creek.

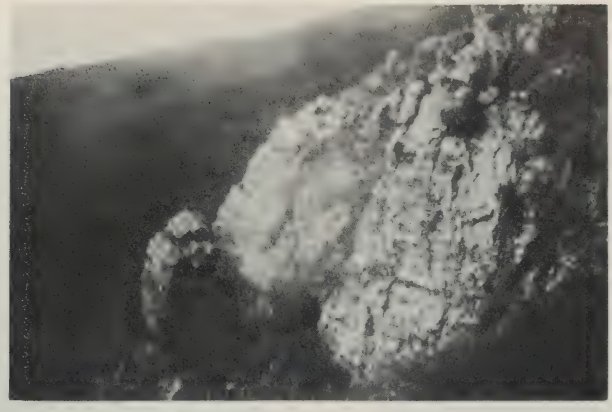


FIG. 21. Columnar jointing in rhyolite. The columns, now gently dipping toward the east, are perpendicular to flow planes tilted 80° W. Southwest slope of Willow Creek Peak.

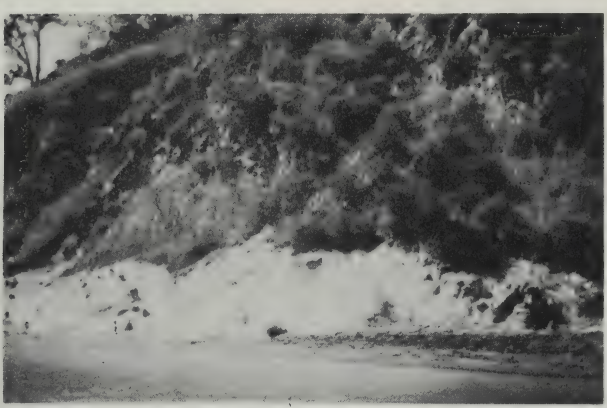


FIG. 22. Cross-bedded concretionary sandstone of Etchegoin group. Top side of beds to the left; beds are overturned toward the northeast. North bank of San Benito River at mouth of Sulphur Creek.

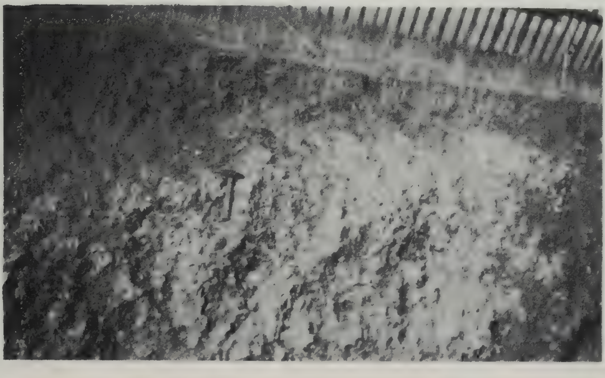


FIG. 23. Oyster beds, containing *Ostrea vespertina* and *Littorina mariana*, near the top of the Etchegoin group. Road cut a quarter of a mile southwest of San Benito.

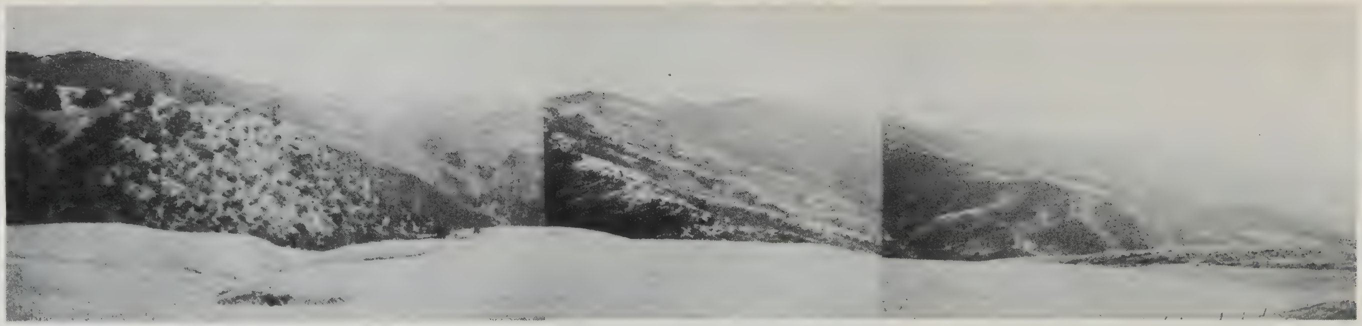


FIG. 24. San Benito gravels, gently dipping northwest. Panoche group underlies the gravels on the left and in the foreground. View southwest from Call Mountains.

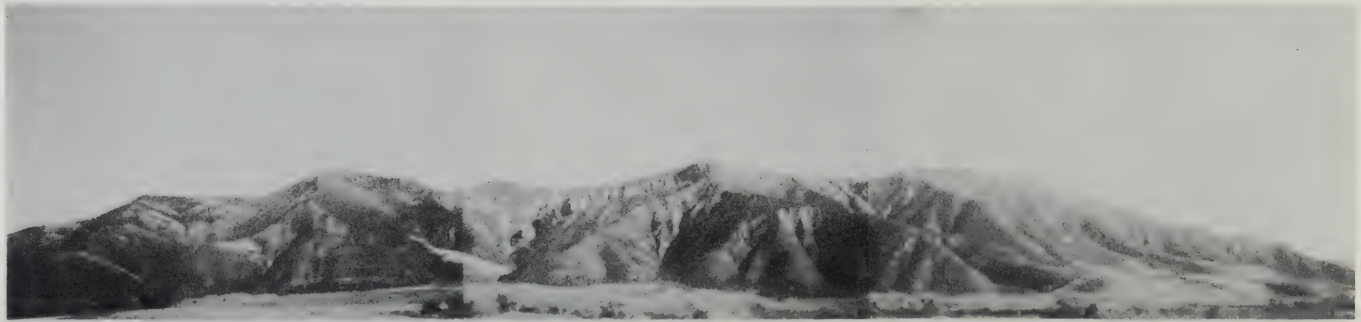


FIG. 25. Etchegoin cliffs east of the San Benito River. The beds are overturned about 60° toward the northeast. Looking northeast from near San Benito.

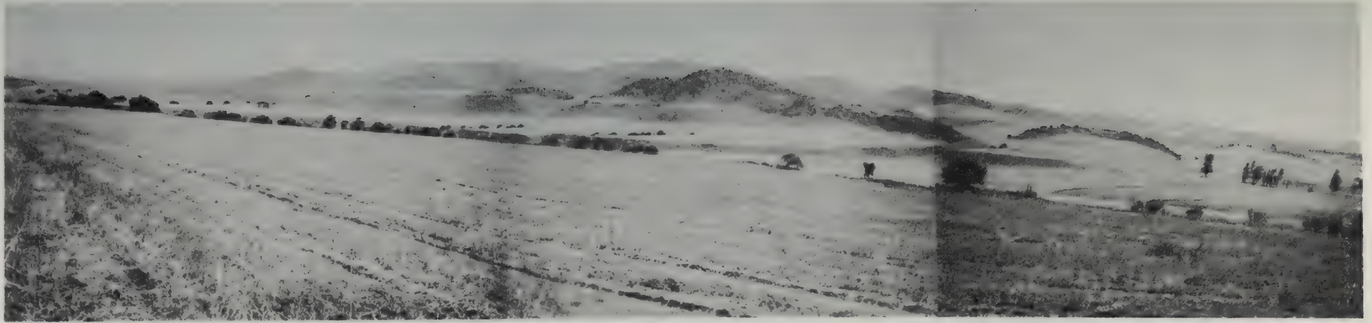


FIG. 26. Terraces north of Tres Pinos Creek. Two levels may clearly be distinguished; toward the right there are three levels. Tres Pinos sandstone forms rocky hills in middle distance; Panoche group forms rounded hills on the skyline.

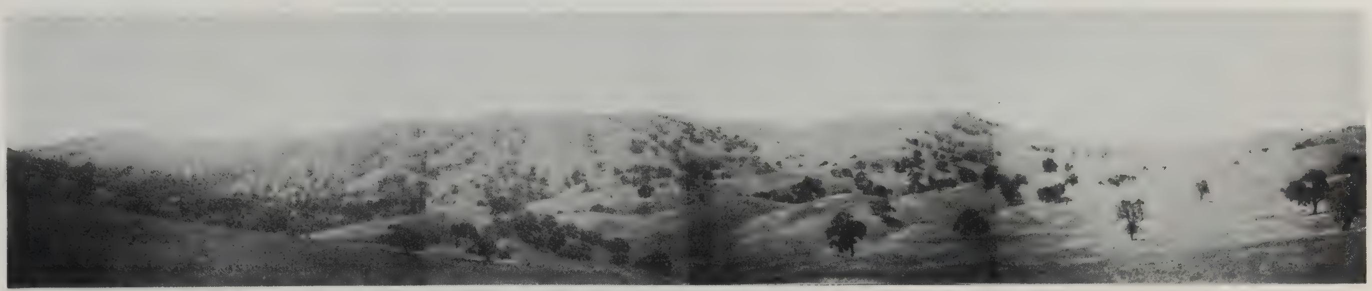


FIG. 27. Two cycles of erosion developed in the Franciscan group in the Diablo Range. View west of Las Aguilas Creek, showing late mature valleys (right) emptying into youthful canyon (left).

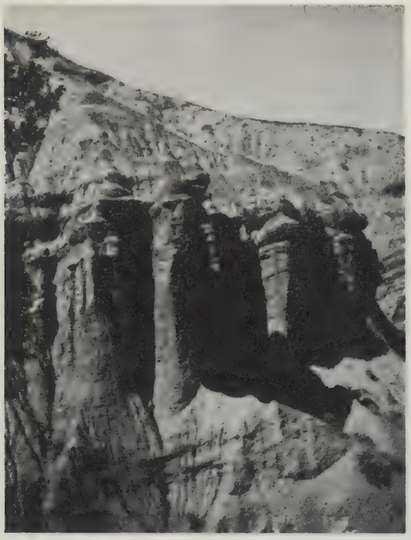


FIG. 28. Cliffs and badlands developed in San Benito gravels north of Tres Pinos Creek just north of Bradford fault.

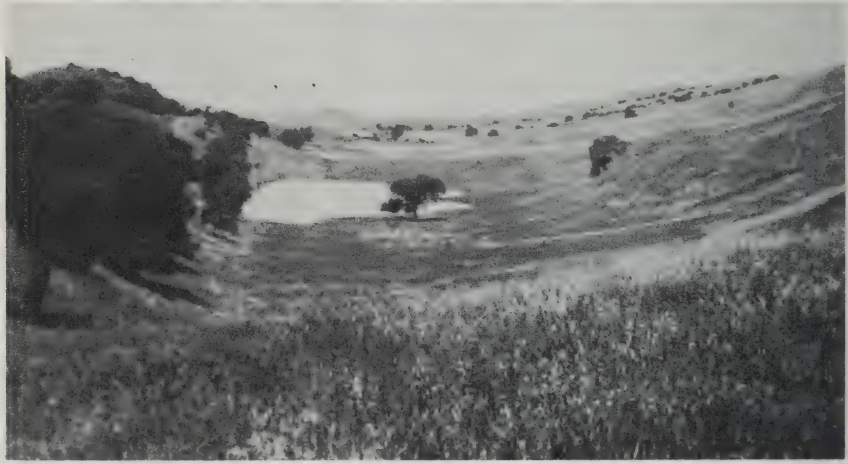


FIG. 29. View northwest along the San Andreas fault, showing sag pond. Northwest of Jungle Inn.

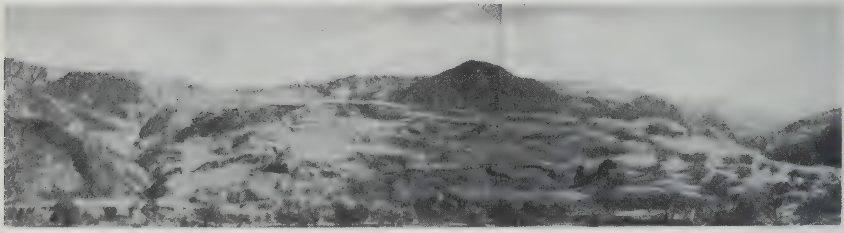


FIG. 30. Large landslide opposite mouth of Willow Creek, looking east. *Photograph by R. W. Swanson.*

The Santa Margarita is fairly resistant to erosion, forming comparatively steep slopes. It is covered chiefly by low brush of the sagebrush type, especially on southerly slopes, and by oaks and grass on some of the northerly slopes.

The typical strata of the Santa Margarita are well-cemented grayish to whitish calcareous sandstones, containing ''reef'' beds of large and small oysters, Pectens, barnacles, and bryozoans. Some ''reef'' beds are composed almost entirely of comminuted fragments of small oyster shells. There are also beds of gray marl, weathering to a characteristic lumpy surface, which contain abundant molds of Crepidulas and pelecypods.

A small body of rather pure opaline chert was found near the top of the Santa Margarita, half a mile south of Pine Rock. Beds of light-gray limestone occur elsewhere, grading into arenaceous limestone and calcareous sandstone. Dark-colored clay-shale is rather common toward the bottom of the exposed section. Some of this contains diatoms. Interbedded brownish sandstones and clay-shales, similar to those of the Etchegoin, are common in the lower part of the section. The uppermost beds in places have been stained reddish by surface waters flowing from the overlying basal red beds of the Etchegoin group. The strata may thus be confused with the red beds from a distance, but close examination reveals the superficial character of the coloration.

Lenticular pebbly conglomerate layers occur at various places in the Santa Margarita formation. One layer about 4 feet thick was examined west of Pine Rock. It contains subrounded to subangular pebbles, averaging ½ to 1 inch in diameter, ranging up to 5 inches. Large oysters occur in the conglomerate, also below and above it. Slightly more than half the pebbles are of Franciscan origin, and consist of green, red, gray, white, and varicolored chert; bluish-gray well-cemented feldspathic sandstone, silica-carbonate rock, serpentine, and greenstone. The remaining pebbles are chiefly pre-Franciscan, mainly porphyries, as well as some black quartzite, light-colored quartzite, and black chert. Other pebbles noted include vein quartz, a few uncertainly identified as flow-banded rhyolite, one of biotite granite, and two light-colored sandstones (probably Tertiary).

The Santa Margarita formation contains abundant fossils, belonging to a relatively few species. The most characteristic forms are *Ostrea titan* var. *eucorrugata, Pecten crassicardo,* and *Pecten estrellanus.* The last two species range down into the Temblor, but B. L. Clark, who examined the specimens, states that these appear to be of the Santa Margarita type (upper Miocene). One incomplete specimen of an *Astrodapsis* was found, which resembles *A. margaritanus,* believed to be characteristic of the Santa Margarita. Bryozoans and large Tamiosomas are abundant.

The following species were determined by B. L. Clark and the writer:

ECHINOIDEA
Astrodapsis cf. margaritanus Kew

BRYOZOA
Undetermined

PELECYPODA

Apolymetis biangulata (Carpenter)
Clementia (Egesta) martini (Clark)
Cryptomya sp.
Ostrea titan Conrad var. eucorrugata Hertlein
Ostrea sp. (small)
Pecten (Lyropecten) crassicardo (Conrad)
Pecten (Lyropecten) estrellanus (Conrad)
Protothaca staminea (Conrad)
Pseudocardium densatum (Conrad)
Thracia sp.

GASTROPODA

Crepidula praerupta Conrad
Natica ? sp.
Surculites (Megasurcula) cf. carpenterianus (Gabb)

CIRRIPEDIA

Balanus concavus Bronn
Tamiosoma gregaria Conrad

PISCES

Undetermined fish remains

MISCELLANEOUS

Diatoms, including Coscinodiscus ?

A sample of clay-shale from near the bottom of the Santa Margarita was examined microscopically by H. G. Schenck. He reports abundant fish remains; also diatoms, many of which are large, discoidal types, probably including *Coscinodiscus.* He states: ''The diatoms are not fragmented, but instead are preserved as unbroken 'pill boxes.' This type of preservation is common in diatomites of Delmontian age.''[8]

Etchegoin Group (Pliocene)

The Etchegoin group (Anderson 05, pp. 178-192) is a series of sandstones, shales, and conglomerates of Pliocene age, whose maximum thickness is 3500 feet. The term is herein used as Nomland (17) used it, to include the Jacalitos, Etchegoin, and possibly also the San Joaquin formations of the Coalinga district, which cannot be distinguished lithologically in the field in this region.[9] Only one cartographic division was separated—a series of red beds of non-marine origin at the base, which is of quite different character from the rest of the group.

The Etchegoin group lies chiefly in a narrow belt, 2 miles wide, between the San Andreas and San Benito fault zones. Here it reaches its maximum thickness of 3500 feet. In the Sulphur Creek area the Etchegoin extends 2 miles farther east, overlapping the sediments of the Butts Ranch syncline, but with a reduced thickness of only 750 feet. The main belt, along the San Benito River, continues northwest of the quadrangle beneath the San Benito gravels and reappears in the Lomerias Muertos, northwest of Hollister (Kerr and Schenck 25, fig. 3). To the southeast the belt extends through Priest Valley and Waltham Canyon (where it has a thickness of 8000 feet) into the Coalinga district.

The basal red beds of the main Etchegoin belt rest disconformably upon the Santa Margarita formation southwest of the San Benito River.

---

[8] Letter dated February 15, 1941.

[9] Although there is a disadvantage in using the same name for a group and a formation within the group, the alternative of supplying a new name for the group would seem even more objectionable in this case. The well-known term Etchegoin has been perhaps as widely used as a "group" term (Nomland 17; Reed 33, pp. 235-236) as in the more restricted sense. It is conveniently used as such in many parts of the Coast Ranges where the Pliocene section cannot be subdivided into units corresponding exactly with those of the Coalinga district (Woodring, et al. 40, p. 27), even though faunal evidence of these various divisions may be present.

One bit of evidence for the disconformity is the discovery in the red beds of a rounded, reddish-stained fragment of *Ostrea titan* derived from the Santa Margarita. In places there appears to be a difference in dip between the two formations, but this is uncertain because the attitudes of both are so variable. The eastern belt of Etchegoin rests with as much as 90° angular discordance upon the Upper Cretaceous, middle Eocene, and middle Miocene sediments of the Butts Ranch syncline.

The interbedded sandstones and shales of the Etchegoin vary in their resistance to erosion. Where the sandstones dip steeply, they generally produce narrow ridges separated by troughs or low, slumped belts of shale. The basal red beds are less resistant than the overlying sandstones and shales and form more gentle slopes. The formation is generally covered by low brush of the sagebrush type, or in places by dense chaparral (chamise and manzanita). Some of the northerly slopes support oaks and grass. The basal red beds are covered only by grass, or by grass and scattered oaks.

The Etchegoin group consists mainly of poorly sorted cross-bedded brownish sandstones, pebbly conglomerates, and dark-colored clay-shales. Massive concretionary sandstones with reddish-brown ''cannon-ball'' concretions 2 to 3 feet in diameter are common. Well-cemented calcareous sandstone ''reef'' beds containing chiefly *Dendraster gibbsii* and *Anadara trilineata* frequently occur. The sandstones contain subangular grains of quartz, feldspars, biotite, amphiboles and pyroxenes, rock fragments, and a variety of heavy accessory minerals, including such uncommon types as staurolite and kyanite. Clinozoisite, enstatite, epidote, garnet, glaucophane, green hornblende, magnetite, rutile, sphene, and zircon are also present. The source is evidently mixed. Some of the ''blue sandstones'' which are common in the Coalinga district appear in the Etchegoin south of San Benito. The color results from a thin glaucous coating on many of the sand grains, which has often been attributed to opal.

The shales of the Etchegoin vary from well-bedded chocolate-brown clay-shales to lighter-brown silty micaceous shales. These commonly occur as definite units 10 to 50 feet thick. They are often gypsiferous. Sandy shales and shaly sands are also interbedded with the sandstones in layers a few inches thick.

Loosely compacted oyster beds, composed largely of shells of *Ostrea vespertina* in a buff sandy matrix, appear near the top of the formation. Impure marly limestone occurs near the base, just west of Pine Ridge.

Conglomerates in the Etchegoin generally contain only small pebbles, ½ to 2 inches in diameter, although some range up to 6 inches. Most of the pebbles are subangular to subrounded. The pebbles are chiefly of Franciscan source, including Franciscan sandstone, chert, glaucophane schist, and altered basic igneous rocks. Pebbles of Cretaceous sandstone are common. The usual well-rounded pre-Franciscan porphyries, black cherts, and quartzites are also represented. Granite pebbles are rare.

Stratigraphic Section

The best-exposed section across the Etchegoin group is along Sulphur Creek and the San Benito River west of the mouth of the creek.

The beds stand nearly vertically throughout, facilitating measurement of thickness. Here are nearly continuous exposures of about 3400 feet of beds. Both the base and top of the formation are faulted out. Probably not more than 100 feet of beds are missing at the base; the missing thickness at the top is unknown but is probably not more than a few hundred feet. This section was measured as follows (thicknesses measured with tape to nearest foot):

Section of Etchegoin Group Along Sulphur Creek and San Benito River

		Thickness (feet)
	Top not exposed (within 50 feet of fault contact with Franciscan)	
1.	Sandy shale and sandstone	35
2.	Massive gray medium-grained sandstone; with a few finer-grained brownish sandstone partings, 1 to 2 feet wide, containing abundant fossils, chiefly *Anadara trilineata*	50
	No exposure	29
3.	Fine-grained brownish silty micaceous shale. *Anadara trilineata, Schizothaerus nuttallii* var. *pajaroanus, Polinices*	16
4.	Massive light-brown cross-bedded sandstone, with brownish concretionary layers	36
5.	Chocolate-brown clay-shale, highly fractured, stained reddish brown on fractured surfaces. Much gypsum. *Anadara trilineata, Mytilus coalingensis, Protothaca tenerrima, Schizopyga moraniana, Thais canaliculata, Olivella biplicata*	55
6.	Massive gray to light-brown concretionary sandstone	105
	No exposure	160
7.	Bluish-gray silty micaceous shale	8
8.	Massive gray sandstone	6
	No exposure	10
9.	Fine-grained brownish sandstone	12
10.	Gray coarse sandstone and pebbly conglomerate; pebbles average ¼"-1" in diameter	2
	No exposure	23
11.	Gray medium-grained sandstone	55
12.	Pebbly conglomerate, highly fossiliferous	1
13.	Massive gray medium-grained sandstone, with a few well-cemented concretionary layers averaging 1′ in thickness	47
14.	Pebbly fossil "reef" layer. *Clinocardium meekianum, Macoma vanvlecki, Solen perrini, Spisula coalingensis, Thais etchegoinensis*	2
15.	Fine-grained brownish to gray sandstone and sandy shale	32
16.	Pebbly fossil "reef" layer	1
17.	Massive gray sandstone with fossil "reef" layers. *Trachycardium quadragenarium*	50
18.	Fossil "reef" layer. *Clinocardium meekianum, Pseudocardium densatum, Solen perrini*	2
19.	Massive cross-bedded concretionary gray sandstone, with pebbly well-cemented layers. *Clinocardium, Dendraster*	104
	(Mouth of Sulphur Creek)	
20.	Pebbly well-cemented fossiliferous conglomerate. Pebbles average ½"–1" in diameter. *Anadara trilineata, Thais lamellosa*	6
21.	Medium- to coarse-grained gray sandstone with well-cemented pebbly layers. Pebbles average ¼" in diameter	58
22.	Fine- to medium-grained brownish sandstone, highly fossiliferous. *Anadara trilineata, Moniliopsis mercedensis*	11
23.	Brownish sandy shale and fine-grained sandstone	32
24.	No exposure	50
25.	Chocolate-brown clay-shale, and silty shale. Occasional fossil layers. Much gypsum. *Compsomyax subdiaphana*	74
26.	Brown concretionary sandstone	5
27.	Chocolate-brown gypsiferous clay-shale and silty shale; sandy shale and fine-grained sandstone toward top. *Anadara trilineata, Crepidula onyx, Crepidula princeps*	60
28.	Brownish sandy shale and sandstone	42
29.	Massive brown sandstone, with concretionary layers	32
30.	Brownish sandy shale and sandstone	55
31.	Massive concretionary sandstone. Pebbly conglomerate at base; pebbles up to 3" or 4" in diameter	38
32.	Well-bedded brownish sandstone with thin shaly partings. Light pebbly conglomerate at base	61
33.	Massive brownish concretionary sandstone. *Anadara trilineata*	103
34.	Well-bedded sandstone with thin shaly partings, and occasional pebbly layers	39
35.	Massive brownish sandstone with pebbly layers and concretionary layers	116
36.	Well-bedded sandstone with shaly partings	10
37.	Massive brownish sandstone with pebbly layers and concretionary layers	34

	Thickness (feet)
38. Chocolate-brown gypsiferous clay-shale and silty shale; sandy shale and fine-grained sandstone toward top. *Anadara trilineata, Macoma nasuta, Macoma secta, Mytilus coalingensis, Schizothaerus nuttallii* var. *pajaroanus, Cancellaria rapa, Crepidula princeps, Polinices lewisii*	80
39. Heavy well-cemented conglomerate layer. Pebbles average 2" to 3", up to 6" in diameter	5
40. Massive brown concretionary sandstone	26
41. Sandy shale and sandstone	5
42. Massive brown concretionary sandstone	62
43. Clay-shale and silty shale	7
44. Massive brown sandstone	13
45. Clay-shale and silty shale, more sandy toward the top	38
46. Thin-bedded brown sandstone, with few concretionary layers	41
47. Chocolate-brown clay-shale and brownish silty shale	16
48. Brown concretionary sandstone, with some thin-bedded layers, and occasional fossiliferous layers	137
49. Silty micaceous shale and sandy shale	16
50. Brown concretionary sandstone, with some thin-bedded layers, and occasional fossiliferous layers	85
51. Silty micaceous shale, and chocolate-brown clay-shale, highly fractured, more sandy toward the top	67
(At gate in Sulphur Creek)	
52. Massive brown concretionary sandstone, with prominent fossil "reef" beds. *Dendraster gibbsii, Glycymeris grewingki, Pseudocardium densatum, Pododesmus macroschismus, Calliostoma* cf. *coalingense, Calyptraea filosa, Schizopyga moraniana, Thais canaliculata, Tamiosoma gregaria*	25
53. Fine-grained highly jointed brownish sandstone	32
54. Chocolate-brown clay-shale, highly fractured, stained reddish brown on fractured surface, and silty micaceous shale. *Macoma nasuta, Macoma secta*	73
55. Massive brown concretionary sandstone, with light pebbly layer at base	16
56. Brownish silty shale and clay-shale	23
57. Brownish well-bedded sandstone	45
58. Chocolate-brown clay-shale, highly fractured, stained reddish brown on fractured surface, and silty micaceous shale	64
59. Brownish sandstone "reef" bed. *Anadara trilineata, Protothaca tenerrima, Thais etchegoinensis, Balanus concavus*	2
60. Interbedded brown sandy shale and resistant gray sandstone "reef" beds, with pebbly layers. Sulphur springs. *Mytilus coalingensis, Protothaca tenerrima*	95
61. Massive gray sandstone and "reef" beds. Many sulphur springs. *Dendraster gibbsii, Mytilus coalingensis, Taras parilis, Protothaca tenerrima*	81
62. Brown silty micaceous shale and sandy shale, interbedded with brown sandstone. Some chocolate-brown clay-shale. Highly fractured and brecciated	178
63. Brown concretionary sandstone	16
No exposure	32
64. Brown concretionary sandstone	16
65. Basal red beds. Reddish to bluish poorly sorted gravels, sands and clays. Abundant Franciscan debris. No marine fossils. Horse tooth found just to south of line of section	397
Fault contact with Franciscan.	
Total	3360

Basal Red Beds

The only lithologic division of the Etchegoin group which may be readily distinguished and mapped over the entire area is the basal series of red beds. This is a key horizon which proved of great importance in working out the structure of the region. It clearly marks the contact between the Etchegoin and Santa Margarita, which otherwise would be difficult to locate.

The red beds average 500 feet in thickness, ranging in general from 400 to 600 feet. They occur everywhere that the base of the Etchegoin is exposed, except for the eastern belt overlapping upon the Butts Ranch syncline. They consist mainly of poorly sorted gravels, sands, and clays which nearly everywhere are strongly colored a deep red, with occasional streaks of blue or green. Occasionally the gravels and sands are well cemented into conglomerate and sandstone.

The pebbles average 2 to 3 inches, ranging up to 6 or 8 inches in diameter and are mainly subangular to subrounded. They represent a larger proportion of Franciscan debris than most conglomerates in this region. This includes Franciscan sandstone, serpentine, chert, glaucophane schist, and various altered basic igneous rocks. In addition there are numerous pebbles of brownish to greenish feldspathic, biotitic sandstones which are doubtless Cretaceous, and a few other sandstones which may be Tertiary. The usual well-rounded pre-Franciscan porphyries, black cherts, and quartzites are rarer than in most of the other formations.

The basal red beds are most likely of nonmarine origin. This, of course, is true of red beds in general, although there may be some exceptions. In this case, the lithologic criteria are supported by a certain amount of faunal evidence—the lack of any marine organisms, although these are quite abundant in the overlying Etchegoin; and the presence of vertebrate remains. The latter are very scarce: a horse tooth found by Carl Bleifuss of Hollister just south of Sulphur Creek, and camel remains discovered farther southeast, in the Priest Valley quadrangle. The latter were tentatively placed as Pliocene by R. A. Stirton (Mielenz 39, p. 205).

Overlap of Etchegoin Group Onto Butts Ranch Syncline

The belt of Etchegoin extending east of the San Benito fault zone onto the Butts Ranch syncline in the headwaters of Sulphur Creek differs in several important characteristics from the main belt along the San Benito River: (1) the thickness is greatly reduced, being not more than 700 feet, as compared with 3400 feet in the main belt; (2) the deposits are much coarser, consisting mainly of gravels and heavy conglomerates, interbedded with sandstone; pebbles and boulders are commonly 6 to 8 inches in diameter; there is practically no shale; (3) faunal evidence indicates that only the Etchegoin proper (middle Pliocene) is present.

These characters point to a shoreline encroaching to the east over the previously folded Butts Ranch syncline during Etchegoin (middle Pliocene) time. The coarseness of deposits, abundance of boulders, and relative absence of shale indicate close proximity to a shoreline lying to the east. This is borne out by the great reduction in thickness in this direction. It is doubtful if the sea extended much farther east than the present position of these deposits, 1 mile west of Butts Ranch. Following the Butts Ranch syncline eastward to Pimental Canyon in the Panoche quadrangle, only nonmarine Pliocene red beds are found.[10]

A similar eastward transgression of the Etchegoin, compared with the Jacalitos, occurs southeast of this area in the White Creek syncline, according to Nomland (17, p. 198). He states:

> "In the White Creek Syncline the lower part of the upper Etchegoin rests uncomformably on the upper Cretaceous. The basin of deposition of the upper Etchegoin evidently had a greater extent in this direction than in the lower Etchegoin, as shown by this overlap."

Fossils, Correlation, and Age

The Etchegoin group contains the most abundant and best preserved fossils found in this region. A total of 68 species was identified. The fauna consists dominantly of pelecypods, and subordinate gastropods. The echinoid *Dendraster gibbsii* is common in sandstone "reefs."

The Jacalitos (lower Pliocene) and Etchegoin (middle Pliocene) divisions of the Coalinga district are both present, and the San Joaquin

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[10] Mielenz, R. C., personal communication, 1939.

(upper Pliocene) may also be represented. The Jacalitos is established by the presence of the forms *Astrodapsis spatiosus* and *Pecten estrallanus* var. *terminus,* which are unknown outside of this zone. Other species confined to the Jacalitos in this area, but not so limited in other regions, are *Dendraster ashleyi,* and *Thais* cf. *shumanensis.* Longer-range species occurring with the above forms are *Dendraster gibbsii, Balanus concavus,* and *Tamiosoma gregaria.* The Jacalitos beds were recognized in only two areas: in a narrow belt immediately overlying the basal red beds, southwest of the San Benito River; and in a fault sliver along the Pine Rock fault on the San Benito River bank opposite Buckeye Canyon. The exact boundary between the Jacalitos and Etchegoin could not be established, but the Jacalitos includes at least 400 feet of strata above the basal red beds southwest of the San Benito River.

By far the greatest portion of the Etchegoin group in this region is thought to belong to the restricted Etchegoin, of middle Pliocene age. This includes most of the 3400 feet of strata exposed in the Sulphur Creek section, except for a few hundred feet at the base. Forms believed diagnostic of this formation are *Moniliopsis mercedensis* and *Schizopyga moranianus.* Not so distinctive, but common throughout, are *Dendraster gibbsii, Anadara trilineata, Clinocardium meekianum, Pseudocardium densatum, Schizothaerus nuttallii* var. *pajaroanus, Protothaca tenerrima,* and *Polinices reclusianus.*

The San Joaquin formation (upper Pliocene) of the Coalinga district is believed to be represented by a thin belt of oyster beds at the top of the Etchegoin group. These beds are exposed half a mile west of San Benito, and in a fault sliver along the San Andreas fault zone near the Jungle Inn. The faunal assemblage includes *Littorina mariana, Mya japonica, Macoma irus,* and *Ostrea vespertina.* Arnold (09, p. 43) lists this assemblage from his "upper *Mya* zone" (except that he lists *Ostrea vespertina* as the variety *sequens*) now included in the San Joaquin formation. Nomland (17, p 214) states that *Littorina mariana* is unknown in other horizons, but Woodring et al. (40, p. 60) record this species in the upper part of the Etchegoin as well as in the San Joaquin formation. However, Woodring et al. record *Ostrea vespertina* and its variety *sequens* only from the San Joaquin formation. It seems possible, therefore, that the beds containing this assemblage are equivalent to the San Joaquin formation. If this proves to be true, then at least 300 feet of beds west of San Benito belong to the San Joaquin formation, the base of which could not be established.

The fossils in the following list were determined by B. L. Clark and the writer.

ECHINOIDEA

Astrodapsis spatiosus Kew
Dendraster ashleyi Arnold
Dendraster gibbsii (Rémond)

PELECYPODA

Anadara trilineata (Conrad)
Chione elsmerensis English
Clinocardium meekianum (Gabb)
Compsomyax subdiaphana (Carpenter)
Cryptomya californica (Conrad)
Cryptomya quadrata Arnold
Dosinia jacalitosana Arnold

PELECYPODA—Continued

Glycymeris grewingki Dall
Lucina (Lucinoma) acutilineata Conrad
Lucina (Miltha) xantusi (Dall)
Macoma irus (Hanley)
Macoma nasuta (Conrad)
Macoma secta (Conrad)
Macoma vanvlecki ? Arnold
Macoma sp.
Mactra sp.
Mya japonica Jay
Mytilus coalingensis Arnold
Mytilus kewi Nomland
Ostrea vespertina Conrad
Pachydesma stultorum (Mawe)
Pachydesma trigonalis (Nomland)
Pandora punctata Conrad
Panope generosa Gould
Pecten (Lyropecten) estrellanus (Conrad) var. terminus Arnold
Pecten (Patinopecten) healyi Arnold var.
Pododesmus macroschismus (Deshayes)
Protothaca staminea (Conrad)
Protothaca tenerrima (Carpenter)
Pseudocardium densatum (Conrad)
Saxidomus nuttalli Conrad
Schizothaerus nuttallii (Conrad)
Schizothaerus nuttallii (Conrad) var. pajaroanus (Conrad)
Semele ? sp.
Siliqua lucida (Conrad)
Solen perrini Clark
Spisula albaria (Conrad)
Spisula catilliformis (Conrad)
Spisula coalingensis (Arnold)
Spisula hemphilli (Dall)
Taras parilis (Conrad)
Trachycardium (Dallocardia) quadragenarium (Conrad)
Volsella recta (Conrad)
Zirfaea pilsbryi Lowe

GASTROPODA

Calliostoma cf. coalingense Arnold
Calyptraea filosa (Gabb)
Cancellaria rapa Nomland
Crepidula onyx ? Sowerby
Crepidula princeps Conrad
Kelletia (Kelletia) kettlemanensis (Arnold)
Littorina mariana Arnold
Moniliopsis mercedensis (Martin)
Olivella biplicata (Sowerby)
Olivella pedroana (Conrad)
Polinices (Euspira) lewisii (Gould)
Polinices (Neverita) reclusianus (Deshayes)
Schizopyga californiana (Conrad) var. coalingensis (Arnold)
Schizopyga moraniana (Martin)
Thais (Nucella) canaliculata (Duclos)
Thais (Nucella) etchegoinensis Arnold
Thais (Nucella) lamellosa (Gmelin)
Thais (Nucella) cf. shumanensis Carson

SCAPHOPODA

Dentalium sp.

CIRRIPEDIA

Balanus concavus Bronn
Tamiosoma gregaria Conrad

San Benito Gravels (Plio-Pleistocene)

The San Benito gravels (Lawson 93b, p. 153; Kerr and Schenck 25, pp. 468-469, 477, 490) are a thick series of non-marine deposits of Plio-Pleistocene age which blanket much of the northwestern part of the San Benito quadrangle. The formation is younger than the strongest folding which affected the region, and overlaps nearly all of the older formations. It rests with angular discordance of as much as 90° upon the Franciscan and Cretaceous, and as much as 35° upon the Etchegoin group. It has been subjected to gentle folding and faulting of comparatively small displacement.

The main belt of San Benito gravels lies on either side of Tres Pinos Creek, extending as far east as Salt Creek, covering an area about 3 miles wide and 12 miles long. This belt continues northwest into the Gonzales and Hollister quadrangles. The maximum thickness in this belt is over 1500 feet, and may reach 2000 feet. A thickness of 1250 feet is revealed in a single exposure at the head of Sulphur Creek. Other belts of San Benito gravels occur just southwest of the Pine Rock fault, southwest of the San Andreas fault, and in scattered areas covering the Franciscan group. The thickness exposed in these areas is not more than a few hundred feet.

The San Benito gravels are less resistant to erosion than most of the older formations and tend to form broad, gentle dip slopes, and steep scarp-slopes often intricately carved into ''badlands.'' The formation is covered with grass, or with grass and scattered oaks. In some places a sparse growth of short brush of the sagebrush type occurs on the steeper slopes.

Some of the gravels have a gray or whitish appearance which contrasts sharply with the brownish appearance of the Etchegoin; elsewhere they are colored in shades of red, and show smaller areas of blue or green, as in the belt northwest of Los Muertos Creek. The coloration is generally not so pronounced as in the basal red beds of the Etchegoin.

The San Benito gravels consist of gravels, sands, and clays, in part consolidated into conglomerate, sandstone, and clay-shale. The sorting is generally poor, and rapid variations in grain size occur both laterally and vertically. Coarse cross-bedding, channeling, and rapid lensing of gravel layers are prominent features.

The sands and sandstone contain angular to subangular grains of variable size, intermingled with silt and clay. The grains include quartz, feldspar, biotite, many rock fragments, and a variety of heavy minerals, including actinolite, augite, diopside, enstatite, green, brown, and blue-green hornblende, tremolite, clinozoisite, epidote, magnetite, and sphene. Some of the material is incoherent whereas certain beds are well cemented. Bands of stronger cementation sometimes extend through the formation at right angles to the bedding.

Clays, clay-shales, and siltstones occur in distinct beds or intermingled with the beds of sand and gravel. The clays are usually yellowish to brownish in color. They are rather soft, incoherent, and poorly bedded. Occasional beds of impure lignite are interbedded with the clays.

Pebbles in the gravel and conglomerate layers range from a few inches to a foot or two in diameter, and are usually subangular to subrounded, depending upon their size. The pebbles are of a great many different types. Franciscan pebbles are in general most abundant, including typical Franciscan sandstone, chert, serpentine, glaucophane and actinolite schist, and greenstone. Greenish feldspathic, biotitic sandstone pebbles resembling Cretaceous sandstone are often present. Sandstone pebbles and boulders containing Etchegoin fossils sometimes occur, especially in the immediate vicinity of that formation. In some places whitish-weathering siliceous shale pebbles occur, which could have been derived from the Moreno, Kreyenhagen, Temblor, or Monterey shales. Granite pebbles are common in some places, rare in others.

The ''pre-Franciscan'' porphyries, black cherts, and quartzites are less common than in many of the older formations. They are nearly always well rounded, and were evidently derived from previous conglomerates. As would be expected, the relative abundance of the various types of pebbles varies from place to place and is influenced by the immediately underlying or adjacent rock.

In some places, particularly north of Tres Pinos Creek, there occur a great many pebbles of a rather fresh porphyritic volcanic rock. The color is purplish to reddish-brown, and a lens reveals distinct plagioclase phenocrysts $\frac{1}{2}$ to 3 mm in diameter. Microscopically the phenocrysts are seen to be labradorite ($Ab_{45}An_{55}$). They are accompanied by augite, partially or completely filled with magnetite, and needle-like crystals of apatite. The groundmass is hyalopilitic, containing very small lath-shaped crystals or microlites in a brownish glass. This particular pebble would be called basalt, but others might be called andesite. No similar rocks were observed in place or as pebbles in any of the older formations, and their source is unknown; they may have come from a volcanic area lying to the north in the Quien Sabe quadrangle.

The San Benito gravels have yielded a few vertebrate fossils and fresh-water mollusks. Kerr and Schenck (25, p. 476) reported camel remains and horse teeth identified as *Equus* near *occidentalis* Leidy, which they considered of Pleistocene age. However, R. A. Stirton has examined these horse teeth and another submitted by the writer and states that they cannot be placed closer than upper Pliocene or lower Pleistocene.

Fresh-water clams, identified as *Anodonta wahlamatensis,* and undetermined gastropods were found in a fine-grained well-cemented yellowish sandstone. Kerr and Schenck (25, p. 476) reported *Anodonta* sp. and *Pyrgulopsis vatesiana* in the Paicines formation, which they considered of Pliocene age. They state that no contact was found between the Paicines beds and the San Benito gravels and that ''it is practically impossible to separate'' the two; their basis for establishing the two formations was the discovery of Pliocene invertebrates in one area and Pleistocene vertebrates in another. However, the discovery of similar invertebrates by the writer in an area mapped by Kerr and Schenck (25, fig. 3) as San Benito gravels, together with the fact that the vertebrates may be Pliocene or Pleistocene, would seem to eliminate any basis for separating the two formations. No contact of any sort has been found between the beds containing the invertebrate and vertebrate fossils; the lithologies are identical; and since the fossils now apparently signify no difference in age, it seems logical to include these beds in one formation. Hence the term ''Paicines formation'' is not used in this paper; the older term San Benito gravels includes both the Paicines formation and San Benito gravels of Kerr and Schenck.

The best indications from the invertebrate and vertebrate fossils are that the San Benito gravels are upper Pliocene, or Pleistocene, or both.

The San Benito gravels are definitely non-marine deposits, as evidenced by: (1) poor sorting; (2) rapid variation in grain size and character of material, both laterally and vertically; (3) coarse cross-bedding, channeling, abrupt lensing of gravel beds; (4) distinct red and blue coloration in places; (5) presence of non-marine fossils; absence of marine fossils.

The gravels are most likely flood-plain deposits derived by erosion from the ancestral mountains which were formed in this region by the strong upper Pliocene deformation.

Landslides (Quaternary)

Landslides are quite common in the San Benito quadrangle, particularly on the steep front of the Diablo Range just northeast of the San Benito River. Only the more prominent of these were mapped. The slides have developed from various formations, but chiefly from Franciscan serpentine, the relatively unconsolidated San Benito gravels, and soft Cretaceous shales.

The largest landslide lies northeast of the mouth of Willow Creek. It has a length of 1½ miles and an average width of half a mile. The surface has an average slope of 9°. It heads in Franciscan serpentine and the basal red beds of the Etchegoin, but it also includes large blocks and smaller debris of the Etchegoin and San Benito gravels. A much smaller, more recent mass of serpentine has flowed over this landslide near its head.

An interesting recent mudflow is developed from the San Benito gravels in sec. 30, T. 15 S., R. 8 E., M. D., and sec. 25, T. 15 S., R. 7 E., M. D. A considerable movement on this slide followed some severe storms in the spring of 1938. The flow dammed up the stream at its foot, forming a lake behind it. In the summer of 1938 this lake rose nearly to the top of a windmill which had once been placed in the stream bed.

Terrace Deposits (Quaternary)

Terrace deposits border the two largest streams of the area, the San Benito River and Tres Pinos Creek. They consist of unconsolidated gravel, sand, silt, and clay. Two or three levels occur in many places; these separate levels were mapped wherever possible.

The best developed terraces occur north of Tres Pinos Creek and Los Muertos Creek in the northwestern part of the quadrangle. Here occur as many as six different levels, two of which are very prominent. North of the junction of the two creeks four sets of terraces were noted as follows:

	Height above stream (feet)	*Approximate elevation (feet)*	*Maximum width (feet)*
1	20	770	800
2	50	800	2000
3	150	900	700
4	300	1050	2000

Just west of the McKanna Ranch on the north side of Los Muertos Creek are six terrace levels, as follows:

	Height above stream (feet)	*Approximate elevation (feet)*	*Maximum width (feet)*
1	10	800	900
2	75	865	400
3	100	890	1000
4	120	910	200
5	175	965	500
6	375	1165	800

Alluvium (Quaternary)

Recent alluvium, unconsolidated gravel, sand, silt, and clay, occurs in the beds of many of the larger streams of the region. The largest areas of alluvium are in the first-cycle valleys at the head of Las Aguilas Creek.

STRUCTURE

The San Benito quadrangle is divided into two structural provinces which have different basement rocks and have reacted differently to deformational forces. The Gabilan Range is ''thin blanketed''; it has a granite basement, and a sedimentary cover ranging from 0 to 3000 feet in thickness. It has been deformed chiefly by block faulting, and some gentle folding of the thicker sedimentary sections. The Diablo Range is ''thick blanketed''; it has a basement of at least 10,000 feet of easily foldable Franciscan strata, overlain by as much as 13,000 feet of later sediments. It has been deformed by folding and thrust faulting, and strong overturning in places. At least three epochs of folding are represented. The boundary between the two basements is formed by the Bear Valley fault, lying close to and roughly paralleling the San Andreas fault zone.

Diablo Range

The Diablo Range comprises the following structural belts, from southwest to northeast:

1) The San Benito River area, a belt of highly folded, overturned, and faulted Franciscan, upper Miocene, and Pliocene strata between the Bear Valley fault and the San Benito fault zone. It includes the San Andreas, Pine Rock, and Paicines faults. The deformation was chiefly upper Pliocene, with some reversals of fault movements indicated in the Pleistocene or Recent.

2) The Butts Ranch syncline in the southeastern part of the area, strongly folded between the middle Miocene and middle Pliocene (most likely between middle and upper Miocene).

3) A belt of San Benito gravels overlapping the Butts Ranch syncline to the northwest. This was gently warped into a broad, plunging syncline and faulted in the Pleistocene or Recent.

4) A broad expanse of folded Franciscan, the chief fold within the quadrangle being the Tres Pinos syncline. The main folding may have occurred at the same time as that of the Butts Ranch syncline. The belt is bounded on the southwest by the Browns Valley and Bradford faults, which have thrust Franciscan over the Cretaceous, probably during the upper Pliocene. The Bradford fault shows reversal of movement in the Pleistocene or Recent.

The various structural features will be discussed in turn, considering first the faults, then the folded structures.

San Andreas Fault Zone

The San Andreas fault, longest-traced fault and most important known active fault in California, extends in a northwest direction through the San Benito quadrangle. It is known to extend north as far as Point Arena and south to Imperial Valley.

The fault plane is essentially vertical, as indicated by the straight course across irregular topography. Recent movement along the fault has been chiefly horizontal, the southwest side having moved relatively northwest. This was demonstrated during the San Francisco earthquake of 1906, when a maximum horizontal displacement of 21 feet was measured. It is also indicated by stream offsets.

The San Andreas fault in part of this area consists of two or more subparallel faults with occasional en echelon branches, all of which show topographic evidence of recent movement, such as sag ponds, narrow troughs, scarps, and other rift features. The sum total of these breaks showing evidence of active horizontal movement is herein referred to as the San Andreas fault zone. As thus defined the fault zone has a width of 50 to 1500 feet, averaging 500 feet. This definition excludes nearby thrust faults which have sometimes been included in the San Andreas fault zone, but which possess an entirely different character and history.

Horizontal displacement of about half a mile is shown by offsets of streams and ridges along the San Andreas fault. This is best shown northeast of Little Rabbit Valley, just south of the San Benito quadrangle, in the Metz quadrangle. Here two southwestward-flowing streams have been deflected 1600 and 2700 feet to the northwest on the southwest side of the fault.

Displacements of several tens of miles along the San Andreas fault have been suggested in the past, but evidence against such large displacements has been presented by Reed (38) and by Taliaferro (38). In this area no evidence was found for displacements of any greater magnitude than those indicated by the stream offsets.

Bear Valley Fault

The Bear Valley fault marks the boundary between granite basement and Franciscan basement—the geological boundary between the Gabilan and Diablo Ranges. Its course parallels and in part coincides with that of the San Andreas fault, which may explain the attribution of some of its characteristics to the San Andreas fault in the past.[11] However, it deviates southwest from the San Andreas fault as much as half a mile in the San Benito quadrangle. The same or a similar fault has been described by Taliaferro (38) which also diverges southwest from the San Andreas fault, but in part follows its course, in the Priest Valley quadrangle.

The Bear Valley fault differs in several important characteristics from the San Andreas fault: (1) the fault-plane dips northeast, whereas the San Andreas fault-plane is vertical; (2) the Bear Valley fault shows no topographic evidence of recent movement; (3) it shows no evidence of horizontal displacement; (4) the Bear Valley fault shows evidence of movement dating back to the pre-Miocene, whereas no movement earlier than Pleistocene can be demonstrated along the San Andreas.

The Bear Valley fault shows an interesting succession of reversals of movement. These are indicated by the different sequence of formations on the two sides of the fault. The southwest side has a granite basement, overlain by Miocene sediments; the northeast side possesses a Franciscan basement, overlain by the San Benito gravels immediately adjacent to the fault. From these relations, the following movements are postulated (see fig. 6):

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[11] Reed (33, p. 12): ". . . (The San Andreas fault) forms the boundary between a province on the east in which the oldest rocks exposed are . . . the Franciscan formation . . . , and a province to the west in which the Franciscan is not found."

(1) The southwest side of the fault was upthrown and Franciscan was eroded off the granite on this side. Assuming that the fault-plane had its present dip, the movement was of normal type. Probably the entire Gabilan Range was uplifted by the displacement. The movement can be dated in this area only as pre-Monterey (upper Miocene), but elsewhere Taliaferro (41, p. 154) has dated it as post-Cretaceous and pre-Temblor, most likely Eocene.

(2) Franciscan on the northeast side of the fault was thrust over the granite and Monterey on the southwest side. Monterey sediments were eroded from the northeast side of the fault. The displacement was not nearly so great as in the first movement, because granite was still left far below the surface on the northeast side of the fault. The relative movement at this stage is indicated not only by the sequence of formations, but by a synclinal drag in the Miocene sediments on the southwest side of the fault. This movement occurred some time between the upper Miocene and Pleistocene, because the Plio-Pleistocene San Benito gravels are the youngest formation not involved in the action. It probably took place in the upper Pliocene, the demonstrated time of most active thrusting in this region.

(3) The most recent reversal of movement along the Bear Valley fault is a downthrow of the San Benito gravels on the northeast side. The displacement is slight compared to the earlier movements, averaging about 300 feet. Since the San Benito gravels are Plio-Pleistocene, the time of this movement must be late Pleistocene or Recent. It is analogous to a reversal of movement involving the San Benito gravels along the Bradford fault.

The absence of certain formations on one side or the other of the Bear Valley fault might be explained as indicating nondeposition rather than removal by erosion following successive fault movements. But this alternative hypothesis is contradicted by the nature of the sediments adjacent to the fault. If the fault marked a boundary of deposition, a coarsening of texture would be expected immediately adjacent to it. This does not occur in any of the three post-granitic formations involved:

(1) The Franciscan immediately adjacent to the Bear Valley fault shows no change in texture from its normal appearance everywhere in the Diablo Range. Cherts and shales occur against the fault; no conglomerates were observed in its vicinity.

(2) The Monterey shows a coarsening of texture toward the southwest, away from the Bear Valley fault; in fact an interfingering of marine and nonmarine sediments was observed in that direction. No evidence could be found of a shoreline in the vicinity of the fault.

(3) The San Benito gravels are coarse throughout, and it is possible that they were deposited no farther southwest than the Bear Valley fault. However, it seems unlikely that the fault formed a barrier to deposition toward the southwest, because the Monterey on that side is no more resistant than the Franciscan on the northeast, and does not form a topographic cliff against which the gravels might be deposited.

A boundary between rocks as different in character as granite and the Franciscan would naturally form a zone of weakness, which undoubtedly explains the series of successive movements along the Bear Valley fault. The San Andreas fault, which formed later, roughly followed this zone of weakness, but being a vertical shear-fault, it developed a straighter course. It cut across many of the irregularities of the Bear Valley fault, leaving the latter as much as half a mile distant. Since the Bear Valley fault dips toward the San Andreas, the San Andreas must cut across or join the Bear Valley fault at depth. Because the Bear Valley fault marks the original line of weakness along which the San Andreas developed in this part of its course, it might be called the ''ancestral San Andreas fault.'' This ancestral San Andreas fault should be clearly distinguished from the San Andreas fault proper, however, because of its different type of fault-surface, different type of movement, different age and history, and because it probably developed in response to a different set of conditions from that which produced the San Andreas fault.

San Benito Fault Zone and Adjacent Area

The most interesting and complex structural features of the San Benito quadrangle occur along the San Benito fault zone, and in the belt between this fault and the San Andreas fault zone. In order to delineate the structure of this belt, block diagrams have been constructed which represent an area 13½ miles long and 4 miles wide and which show practically the whole extent of the San Andreas and San Benito fault zones within the quadrangle (see fig. 9). Two large blocks give a bird's-eye view of the entire area, and 20 smaller blocks show cross-sections made at intervals of less than half a mile to slightly more than a mile, depending upon the relative complexity and amount of variation along the strike. These sections are numbered from 1 to 20, starting at the southeast end, and will be referred to below by number.

The belt lying between the San Andreas and San Benito fault zones averages 2 miles in width. It consists of Franciscan, Santa Margarita, and Etchegoin strata which are tightly folded, overturned, and faulted. In its simplest aspects in the northwest part of the area, the belt may be said to represent a faulted syncline bordered on the northeast by a faulted anticline overturned toward the southwest (sections 14 to 17, fig. 9). In both directions along the strike, however, other faults enter the picture and the syncline loses its identity, although the faulted anticline, represented by the San Benito fault zone, continues.

The San Benito fault zone is the most important thrust-fault in the San Benito quadrangle. It may be traced for a distance of 14 miles in the quadrangle, and continues to the southeast through the Metz and Priest Valley quadrangles, where it was traced by Mielenz (39, p. 255) at least as far as Hernandez Valley, an additional 14 miles. It is called a fault zone because in places it consists of several closely associated branch faults.

The San Benito is a thrust-fault dipping 50° to 70° NE. Its average strike is N. 45° W. Franciscan and Cretaceous on the northeast have been thrust over Etchegoin on the southwest. The Etchegoin sediments have been overturned from 50° to 65° throughout most of the length of the fault. The belt of overturned Etchegoin sediments averages ½-mile to ¾-mile in width. Clear evidence of overturning was established by determining the top side of the strata by means of cross-bedding, graded bedding, and position of echinoids. In general the basal red beds of the Etchegoin occur immediately adjacent to the fault on its southwest side. These red beds form an important ''key'' horizon, which was found exceedingly useful in working out the structure of this area.

The main thrust-fault of the San Benito fault zone evidently developed along an overturned anticline. For the most part it broke along the crest of the anticline, but in at least three places it broke slightly in back of the crest and left remnants of the original anticline standing in front of (southwest of) the fault. (See sections 2, 14, and 16, fig. 9).

The main thrust-fault has one or more branches in parts of the area. Some of these branches dip toward the main fault, and have displacements in the opposite direction; that is, they dip to the southwest, and the southwest is the upthrown side. (See sections 5 to 7 and 15 to 18, fig 9). These may actually be later faults which have cut the San Benito fault, rather than branches. In any event they show evidence of late movement, since they displace the San Benito gravels, whereas the major thrusting occurred prior to deposition of the gravels. In places Franciscan serpentine has been squeezed up along both the main and the branch faults.

The San Benito fault zone dies out to the northwest in one of these branches or later faults with a southwest dip. (See sections 18, 19, and 20, fig. 9). To the northwest, overturning of the Etchegoin ceases, and the strata assume a fairly gentle dip toward the southwest. The dying out of the fault is well exposed in the small canyon in the W. ½ sec. 9, T. 15 S., R. 7 E., M. D. In the bottom of the canyon the Etchegoin is overturned 60° to 80° NE., but on the northwest canyon wall the strata are vertical; at the top of the hill they assume a normal dip of about 25° SW.

The major thrusting along the San Benito fault zone occurred after Etchegoin time (middle Pliocene), but before deposition of the San Benito gravels (Plio-Pleistocene). It may thus be closely dated as upper Pliocene. In places there seems to have been reversal of movement in the Pleistocene or Recent, down-dropping the San Benito gravels on the northeast side of the fault (see section 11, fig. 9). This is analogous to reversals of movement along the Bear Valley and Bradford faults. The thrusting must have occurred before deposition of the gravels; otherwise they should have been eroded away from the northeast side of the fault.

Pine Rock Fault Zone

The Pine Rock fault zone lies approximately midway between the San Andreas and San Benito fault zones. It is named for Pine Rock, southeast of the mouth of Sulphur Creek. It follows the course of the San Benito River southeast of Sulphur Creek, and here little can be adduced as to its nature since it is generally buried by alluvium. Its presence is, however, demonstrated by the relations of the beds on either side of the river; on the northeast side are Etchegoin beds overturned toward the northeast; on the southwest side the Santa Margarita dips southwest. Evidently the northeast side has been downthrown (see sections 1 to 6, fig. 9). Two miles east of San Benito the fault is exposed; here it consists of two branches in each of which the Etchegoin is stepped down on the northeast side (see section 1, fig. 9). Farther northwest a splinter of Jacalitos occurs between two branches of the fault (see sections 3 and 4, fig. 9).

Northwest of Sulphur Creek a branch of the Pine Rock fault zone swings to the west (strike N. 65° W.) and has a gentle dip of 40° NE. A thin belt of serpentine has been squeezed up along the fault zone, bounded by Etchegoin on both sides (sections 8 to 11, fig. 9). Another branch, or perhaps a later fault, continues to the northwest, down-dropping the San Benito gravels on the southwest side (sections 11 to 20, fig. 9).

Paicines Fault

The Paicines fault occurs just northeast of the San Benito fault zone in the western part of the San Benito quadrangle (northeasternmost fault shown on sections 15 to 20, fig. 9). It is, however, of quite different character from the faults of the San Benito zone. It may be traced for 5 miles in the San Benito quadrangle and continues at least 4 miles farther through the Gonzales quadrangle. It passes through the large sag pond enlarged into a reservoir a quarter of a mile south of Paicines, after which it is named.

The Paicines, the only fault in this region at all comparable in nature to the San Andreas fault, possesses the following similar characteristics: (1) the fault plane is vertical; (2) it shows topographic evidence of recent movement by sag ponds, troughs, and scarps; (3) it shows evidence of horizontal displacement by stream offsets (though the amount of displacement is much less than along the San Andreas), and it lacks any appreciable vertical displacement.

The Paicines fault lies in the San Benito gravels throughout its extent in the San Benito quadrangle, but it may readily be traced by topographic evidence. It is generally marked by a straight, narrow trough, bounded by small scarps on one or both sides. It is the only fault, other than the San Andreas, that appears clearly on the aerial photographs.

The fault-plane itself is well exposed in the small canyon along the township line between sec. 32, T. 14 S., R. 7 E., M. D., and sec. 5, T. 15 S., R. 7 E., M. D. The San Benito gravels have clearly been cut by the fault; on the southwest side they dip 20° W.; on the northeast side they show an abrupt right angle difference in strike, and dip 10° N. The relative vertical displacement is not clear, however, and must be slight to allow the gravels to occur on both sides of the fault.

The Paicines fault lies just 1¾ to 2 miles northeast of the San Andreas and closely parallels it in trend (average strike N. 42° W.). Stream offsets show that the southwest side of the fault has moved relatively northwest, as in the San Andreas fault, the possible displacement being 200 or 300 feet. The Paicines and San Andreas faults have undoubtedly developed in response to the same forces. They are the only faults in this area which may be considered "active."

Bradford and Browns Valley Faults

The Bradford fault forms the contact between the Franciscan and Panoche along the north side of the Call Mountains. It is named for the Bradford mine, which is located close to its course three-quarters of a mile southeast of Tres Pinos Creek. The fault may be traced for a distance of 6 miles. It leaves the Franciscan-Panoche contact toward the east, passing into the Franciscan, where its presence is shown by a zone of anomalous strikes. To the west it disappears in the San Benito gravels. The general trend is N. 60° W.

The Bradford fault is a thrust-fault, the fault surface dipping 60° to 80° NE. Franciscan on the northeast has been thrust over Panoche on the southwest. The thrusting occurred before deposition of the San Benito gravels, and is probably of upper Pliocene age.

The most interesting feature of the fault is the evidence of reversal of movement after deposition of the San Benito gravels. At Vasquez Rock, a quarter of a mile north of Tres Pinos Creek, the San Benito gravels have been downthrown on the northeast side of the fault, upthrown and locally eroded away from the southwest side. The gravels have been displaced 300 feet, in a direction opposite to that in which the Franciscan was thrust over the Panoche. (See fig. 7). This movement took place in the Pleistocene or Recent.

The Franciscan-Panoche contact in the northwest part of the quadrangle is formed by the Browns Valley fault. The fault surface dips about 80 degrees to the northeast, from which side Franciscan has been thrust over the Panoche. The fault disappears to the southeast beneath the San Benito gravels. The entire displacement along this fault appears to have occurred prior to deposition of the San Benito gravels.

Butts Ranch Syncline

The Butts Ranch syncline is the most prominent folded structure occurring in the San Benito quadrangle. It is part of a persistent synclinal axis which extends 25 miles to the southeast through Pimental Canyon into the Vallecitos. The syncline is a rather broad open fold in the Vallecitos (Anderson and Pack 15, plate I), but becomes progressively more highly compressed toward the west. In the San Benito quadrangle the dips on the synclinal flanks are rarely less than 60° and are often close to vertical or are overturned. The syncline is cut by a number of small transverse faults, and a longitudinal fault has repeated some of the section on the northeast side.

The syncline has an average strike of N. 65° W. in the San Benito quadrangle. This trend is closer to east-west than those of the structures between the San Andreas and San Benito fault zones, and is believed to follow roughly the course of an Eocene and Miocene seaway which ran obliquely across the present trend of the Coast Ranges.

The Butts Ranch syncline is overlapped to the northwest by the San Benito gravels, and in part by the Etchegoin group. The axis is buried west of the course of Salt Creek. It may continue beneath the San Benito gravels and connect with a syncline found in the Eocene Tres Pinos formation north of Paicines in the Gonzales quadrangle, but this is conjectural.

The most important bit of evidence concerning the age of folding of the Butts Ranch syncline is the overlap of the Etchegoin group onto the syncline near the head of Salt Creek. Here nearly flat-lying beds carrying abundant Etchegoin fossils rest upon the upturned edges of the syncline with an angular discordance of as much as 90° (see fig. 8). The syncline was folded before deposition of the Etchegoin, in other words, before the middle Pliocene (since the fossils in this area are of restricted Etchegoin, middle Pliocene, age; not Jacalitos or San Joaquin). The youngest formation folded in the syncline is the Temblor upper sandstone, middle Miocene; which places the time of folding between the middle Miocene and middle Pliocene. Although the folding could conceivably have occurred at nearly any time during that interval, three main possibilities suggest themselves: (1) post-Temblor, pre-Santa Margarita; (2) post-Santa Margarita, pre-Jacalitos; (3) post-Jacalitos, pre-Etchegoin.

Of these the first possibility seems most likely to the writer, that is, between the middle and upper Miocene. This was the time of greatest shift in distribution of Tertiary deposits in this region.

Structure of San Benito Gravels

The main belt of San Benito gravels, lying between the San Benito fault zone and Tres Pinos Creek, is folded into a broad, gentle syncline, plunging toward the northwest. The synclinal axis strikes about N. 45° W. It extends from Salt Creek northwestward beyond the limits of the quadrangle near Paicines. The inward dips on the flanks and along the plunge of the syncline average 10° to 20°. Higher dips of as much as 60° occur only adjacent to faults. This syncline forms a rough northwestward continuation of the much more highly folded underlying Butts Ranch syncline, and may be an expression of later, more gentle folding of the older syncline.

A small northeast-trending fault cuts the gravels just south of Cottonwood School, upturning them nearly 90° on the northwest side. Just north of Tres Pinos Creek, west of the Elkhorn Ranch, the formation is traversed by a northwest-trending fault.

The fairly gentle folding of the San Benito gravels stands in sharp contrast to the strong folding of the underlying rocks, such as those of the Butts Ranch syncline, the Franciscan north of Tres Pinos Creek, the overturned Etchegoin of the San Benito River area, and the Panoche of the Browns Valley area. In the last-named locality the San Benito gravels have a uniform dip of 6° to 8° S. over the vertical edges of the Panoche.

Structure of Franciscan

The main belt of Franciscan in the San Benito quadrangle is folded into a syncline or synclinorium, herein called the Tres Pinos syncline, whose axis runs roughly east-west just north of Tres Pinos Creek. The folding is not so strong as might be expected, the dips averaging not more than 40° to 50°. In places the axis is fairly sharp, but elsewhere there are several subsidiary axes. On the south side of the structure a considerable amount of wrinkling occurs as the Bradford fault is approached. In the headwaters of Las Aguilas Creek in the northeastern part of the quadrangle the structure loses its identity and possibly merges into an anticlinorium lying to the north. However, the very poor exposures in this region of the first-cycle mature valleys make interpretation of the structure difficult. The synclinal axis is best exposed in Sulphuritos Creek and the area just to the east. An interesting feature is its extension through a belt of glaucophane schist in Willow Springs Creek. The planes of schistosity, which are parallel to the original bedding of the sediments, reflect the synclinal folding as do the unmetamorphosed sediments on either side.

In many places in the Franciscan, northeast strikes occur locally, often closely adjacent to the more normal east or northwest strikes. Although in places these may be due to faulting, they more commonly seem to represent actual wrinkles in the structure. They may be remnants of an earlier folding trending northeast, upon which has been superimposed the later northwest-trending folding seen in the younger Coast Range formations. The general eastward trend of the synclinorium in the Franciscan of this area probably represents an earlier period of folding than that of the San Benito River area. The structure may have formed at the same time as the Butts Ranch syncline.

Gabilan Range

The Gabilan Range, composed of a small to moderate thickness of sediments and volcanics resting on a granite basement, has been deformed chiefly by block faulting. The faults trend in various directions, mainly north, northwest, and northeast.

The most important fault is the Pinnacles fault, which has a northward trend. It is a normal fault, dipping 60° to 70° E . Miocene volcanics and sediments have been downdropped on the east; granite upthrown on the west. This fault may be traced for a distance of 6 miles within the quadrangle.

The Chalone Creek fault was mapped and named by Andrews (36, p. 30) in the Metz quadrangle, and it extends about 1½ miles into the San Benito quadrangle. It trends N. 30° W. Monterey sediments on the east side have been downdropped against the older Miocene volcanics on the west. The dip of the fault plane is not apparent.

The only important folds in the Gabilan Range are some small synclines in the Monterey sediments just southwest of the Bear Valley fault and San Andreas fault zone. One of these occurs near the southern edge of the quadrangle, with dips of about 70° on the two flanks. Two miles southeast of Live Oak School is a much gentler syncline with inward dips of about 10°.

Between Chalone Creek and Bickmore Canyon the Monterey strata are tilted at angles of 25° to 35° NW. In fault contact with this belt farther east (between Chalone Creek and Bear Valley) is a broad expanse of Monterey sediments dipping about 10° S.

The granite in the southwestern part of the San Benito quadrangle is cut by a series of middle Miocene rhyolite dikes, whose pattern gives some indication of the Miocene structure of that region. The dikes have been emplaced along fractures trending in general N. 30° W., and dipping 55° to 65° NE. A very few small dikes have some other directional trend. The longest continuous dikes are about 2 miles in length. The fractures along which the dikes are emplaced are presumed to have been normal faults.

STRUCTURAL HISTORY

Pre-Miocene Structure

The earliest structural event of which we have any record was the division of the region into two provinces with separate basement rocks —the Gabilan Range with a granite basement, and the Diablo Range with a Franciscan basement. The division occurred by movement along the Bear Valley fault, the southwest side having been relatively upthrown and the Franciscan eroded from the granite basement. The fault movement was of a normal type.

The time of first movement along the Bear Valley fault can be dated in the San Benito quadrangle only as pre-Monterey, but has been dated elsewhere as post-Cretaceous, pre-Temblor, and is believed to be Eocene by Taliaferro (41, p. 154).

Gentle folding of pre-Domengine, post-Capay (middle Eocene) age is recorded locally to the east in the Panoche quadrangle, and is indicated to some extent in the San Benito quadrangle by overlapping of the Domengine sandstone onto various Cretaceous and middle Eocene formations.

Middle Miocene Faulting in Gabilan Range

The Gabilan Range was cut during the middle Miocene by a series of normal faults or fissures, along which rose abundant rhyolite dikes. These have a general strike of N. 30° W., and dip toward the northeast.

Middle Miocene-Middle Pliocene Folding

The first important period of folding involved the Butts Ranch syncline. This may be dated definitely only as occurring sometime between the middle Miocene and middle Pliocene, but it seems most likely that it occurred between the middle and upper Miocene. The structural trend of the syncline is more nearly eastward than that of later features. The development of the Tres Pinos syncline in the Franciscan, also having a general eastward trend, may have occurred at the same time.

Upper Pliocene Deformation

The strongest deformation occurred in the upper Pliocene. This produced intense overturning and thrusting along the San Benito fault zone. Thrusting along the Bradford, Browns Valley, and Bear Valley faults probably occurred at the same time.

Late Pleistocene and Recent Deformation

The San Benito gravels (Plio-Pleistocene) have been gently folded into a broad, plunging syncline, and faulted in places. The faulting has been in part by reversals of movement along earlier thrust-faults, as along the Bradford, Bear Valley, and probably also the San Benito fault zone.

Active Faults

The only faults showing topographic evidence of recent movement are the San Andreas and Paicines faults. Both show evidence of horizontal displacement. No antiquity (older than Pleistocene) can be demonstrated for the San Andreas fault in its present form, although in part it follows the course of the Bear Valley fault, whose first movement was pre-Miocene, probably Eocene.

Summary of Structural History

The various periods of deformation represented in the San Benito quadrangle are summarized in the accompanying table.

It should be clear from this survey of structural history that the deformation of the Coast Ranges did not occur in a single period (e.g. Pleistocene) as would be implied by such a term as "Pasadenan" orogeny (Stille 36, p. 867). The "Pasadenan" orogeny in the San Benito quadrangle is represented mainly by gentle folding and reversals of movement on old thrust faults. The Coast Ranges have undergone a complex history of repeated deformations which have not affected all parts of the ranges equally. In particular, the earlier deformations died out toward the eastern margin of the range, along the San Joaquin Valley, which, unfortunately, has been the most studied portion. Here disconformities are described which may be represented elsewhere by profound angular discordances.

PERIODS OF DEFORMATION IN SAN BENITO QUADRANGLE

Age	Type of deformation	Area affected
Eocene ? (post-Cretaceous, pre-Temblor)	Normal faulting along Bear Valley fault. Gabilan Range uplifted.	Gabilan Range.
Middle Eocene (post-Capay, pre-Domengine)	Gentle folding.	Butts Ranch syncline.
Middle Miocene	Normal faulting; faults intruded by rhyolite dikes.	Gabilan Range.
Between middle and upper Miocene ? (post-Temblor, pre-Etchegoin)	Folding.	Butts Ranch syncline; perhaps also main Franciscan area.
Upper Pliocene (post-Etchegoin, pre-San Benito)	Strong folding, overturning, thrust-faulting.	Entire area; most striking results in San Benito River area.
Late Pleistocene or Recent (post-San Benito)	Gentle folding; reversals of movement along upper Pliocene thrust faults.	Probably entire area; results shown in areas covered by San Benito gravels.
Recent ("Active")	Horizontal displacement along San Andreas and Paicines faults.	San Benito River area.

Even earlier disturbances than those found in the San Benito region occur in other parts of the Coast Ranges; for example, a strong Upper Cretaceous orogeny is reported by Taliaferro (41, pp. 131-132) from the Santa Lucia Range. We might generalize that over the Coast Ranges as a whole the last two orogenies—upper Pliocene and Pleistocene—have been the most severe; in the particular area studied, the upper Pliocene deformation was most important.

PALEOGEOGRAPHY

Any discussion of the paleogeography of a region as limited in size as a quadrangle may seem futile, but the San Benito quadrangle is so located as to throw considerable light upon the paleogeography of a fairly large surrounding area. In particular, it shows evidence of at least two separate Tertiary seaways connecting the San Joaquin Valley with the coast.

The name "San Benito trough" has been given to a persistent Tertiary seaway connecting the San Joaquin Valley with the coast across the San Benito region (Clark 30; Reed 38). The term actually covers two separate seaways, however, for the Eocene and Miocene connection was through the Butts Ranch and Vallecitos synclines, whereas the Pliocene seaway had a different course to the southeast through Waltham Canyon. In figures 10 and 11 the term ''Butts Ranch-Vallecitos trough'' is used for the Eocene and Miocene seaway; ''San Benito-Waltham Canyon trough'' for the Pliocene seaway.

Jurassic

The oldest sedimentary formation in the area (except for the Gabilan limestone, about which little may be said) is the Franciscan, Upper Jurassic. Although this is now limited to the northeast side of the Bear Valley fault, it does not seem likely that such was always the case. Reed (33, p. 78) has postulated that ''Salinia'', lying southwest of the San Andreas fault zone, was never covered by the Franciscan. But this seems untenable because of the absence of shoreline deposits in the Franciscan immediately adjacent to the boundary of ''Salinia.'' It is possible, however, that the Gabilan region formed a bank or shelf during the Jurassic over which the Franciscan deposits were relatively thin.

Cretaceous

There is some question as to the extent of the Cretaceous deposits. They may have covered the entire region, or they may have been deposited only in the Diablo Range, where they are now found. At the present time they are not exposed close enough to the Gabilan Range to determine any changes in facies which might indicate shoreline conditions in that direction.

Eocene

The Eocene seas were evidently much more restricted than those of earlier periods. In the heart of the Diablo Range, west of the San Joaquin Valley, their deposits are now found only in the oblique belt represented by the Butts Ranch and Vallecitos synclines—interruptedly continuing to the northwest near the town of Tres Pinos. It seems likely that this represents a strait or seaway connecting the San Joaquin Valley with the Coast during Eocene time.

The minimum extent of this seaway is shown in figure 10 which represents the present distribution of Eocene deposits (exposed or known to be buried by younger deposits) in the area between Hollister and Coalinga. Of course the original distribution of the sea was greater than this—how much greater is difficult to say. It seems doubtful if Eocene deposits covered the Gabilan Range. As already pointed out, this range was uplifted some time between the Cretaceous and middle Miocene, and because of the great amount of erosion which occurred it seems probable that the uplift was Eocene rather than later.

Middle Miocene

Distribution of middle Miocene (Temblor) deposits is similar to the distribution of Eocene deposits, being confined mainly to the Butts Ranch-Vallecitos trough. However, the sea was apparently somewhat broader for it transgressed the Eocene boundaries to the north into the Panoche Valley, and to the south to the vicinity of Red Mountain and the Monterey coal mine, in the Priest Valley quadrangle (Mielenz 39, p. 154).

Upper Miocene

The greatest shift in distribution of seas in this region apparently came between the middle and upper Miocene. The Santa Margarita formation (upper Miocene) is confined to the San Benito-Waltham Canyon trough, running along the San Benito River in this quadrangle and extending southeastward through Waltham Canyon to the San Joaquin Valley. It extends northwestward to the Sargent district, northwest of Hollister.

Some consideration should be given to the Monterey deposits on the east flank of the Gabilan Range. It is difficult to fit them into the paleogeographic picture because of the uncertainty of exact age equivalence with the formations to the east. They may actually be equivalent in time to part or all of the Santa Margarita, despite the great difference in lithologic facies. If so, the eastern extent of this sea would be the same as for the Santa Margarita. But if the Monterey is older, the eastern extent must remain unknown. The western shoreline we can delineate with more certainty, because evidence of it is actually preserved in the sediments on the east side of the Gabilan Range. The gradation of diatomaceous shales toward the west into extremely coarse conglomerates containing granitic and rhyolitic debris has already been mentioned. Evidently the main bulk of the Gabilan Range formed an island at this time, since it contributed so much detrital material.

Pliocene

More information is available concerning distribution of the Pliocene seas than for any of the preceding periods, because of more accurate knowledge concerning directions of thinning and thickening of the sediments, and the occurrence of both marine and nonmarine facies in various places. Figure 11 shows the present distribution of Pliocene deposits between Hollister and Coalinga (including areas in which the deposits are known with reasonable certainty to have been buried or removed).

The main area of Pliocene deposition is here called the San Benito-Waltham Canyon trough, a narrow belt, 2 to 3 miles wide, running southeastward from the Sargent district, through the San Benito River area and Waltham Canyon to the San Joaquin Valley. This is the area of maximum thickness of Pliocene deposits and was evidently a sinking basin, because the thicknesses range from more than 3000 feet in the San Benito area to as much as 8000 feet in Waltham Canyon. In places the sea spread out to either side of this main trough, forming marginal deposits with thicknesses of less than 1000 feet. Examples are the Sulphur Creek area, Hernandez Valley, the White Creek syncline, and the southern extension of the Gabilan Range, called the Gabilan Mesa. In the Sulphur Creek area these marginal deposits show a considerable coarsening away from the main trough, which, combined with a marked thinning of the deposits, indicates a shoreline not far to the east.

Although the southwestern boundary of present distribution of Pliocene deposits in the San Benito region is the San Andreas fault, it is not thought that this was the boundary of the seaway, because of the absence of shoreline deposits immediately adjacent to the fault. The sea undoubtedly extended some distance southwest of the fault, but just how far cannot be determined.

The Pliocene left the earlier Butts Ranch-Vallecitos trough "high and dry" for only non-marine red-bed deposits are found in the Vallecitos syncline, extending to the northwest up Pimental Canyon.

The San Benito-Waltham Canyon trough has a more southeasterly trend than the earlier seaway, having an average strike of N. 45° W., whereas the Butts Ranch-Vallecitos trough, where it cuts obliquely across the range, strikes about N. 70° W. The two seaways are parallel and possibly more or less coextensive from a few miles northwest of Butts Ranch to the vicinity of Tres Pinos, where they are blanketed by Plio-Pleistocene deposits.

SUMMARY OF GEOLOGIC HISTORY

Sometime before the Jurassic, possibly as far back as the pre-Cambrian, the Gabilan limestone was deposited in the Gabilan Range. This was metamorphosed and intruded by the Santa Lucia granite.

In the Upper Jurassic a thick sequence of terrigenous sediments (Franciscan group) was deposited. These sediments, dominantly arkosic, were probably derived from rapid erosion of a mountain range lying to the west of the present Pacific shoreline. Intercalated with the clastic sediments are pillow basalts and radiolarian cherts, most likely produced by submarine volcanism. The entire sequence was cut by ultrabasic intrusives, altered to serpentine, which pneumatolytically metamorphosed the wall rock locally into glaucophane and actinolite schists.

Deposition, mainly of shales, continued through the Upper Jurassic and Lower Cretaceous to form the Knoxville and Paskenta formations. The land-mass supplying detritus was probably of lower relief than it had been during the Franciscan. The middle Cretaceous Horsetown formation is absent and may never have been deposited in this area. Thick clastic sediments accumulated during the Upper Cretaceous. Consisting dominantly of arkosic sandstones and interbedded shales, these were probably derived by fairly rapid erosion from a granitic land-mass.

Paleocene and early Eocene sediments appear to be absent in this region. However, a complete sequence of middle and upper Eocene sediments is represented. These are sandstones and shales deposited in the Butts Ranch-Vallecitos trough.

The Oligocene and lower Miocene rocks are missing, unless they may be represented by some of the Kreyenhagen and Temblor beds. Middle Miocene sandstones and shales derived largely from erosion of the Franciscan were deposited in the Butts Ranch-Vallecitos trough. Sometime during the Miocene, probably in the middle Miocene, extensive volcanism occurred in the Gabilan Range. Rhyolite and more basic flows were poured out, culminating in explosive eruptions of vulcanian type, which produced thick rhyolitic pyroclastics.

In the upper Miocene thick arkosic sandstones and conglomerates of the Monterey group were deposited on the east flank of the Gabilan Range. These grade from coarse non-marine deposits into marine sediments including diatomaceous shales toward the east. Contemporaneously or later in the upper Miocene littoral Santa Margarita deposits accumulated along the San Benito-Waltham Canyon trough. These were derived mainly from the east, whereas the Monterey sediments were derived entirely from the west.

Pliocene seas then invaded the San Benito-Waltham Canyon trough forming highly fossiliferous littoral deposits corresponding to the Jacalitos, Etchegoin, and probably the San Joaquin formations of the San Joaquin Valley. The upper Pliocene folding and accompanying uplift resulted in Plio-Pleistocene flood-plain deposits which blanketed much of the region.

Following the last Pleistocene folding and uplift, two cycles of erosion ensued, the first reaching a stage of late maturity, the second a stage of late youth or early maturity.

MINERAL RESOURCES

Quicksilver

The *Bradford mine* is located south of Tres Pinos Creek, 25 miles southeast of Hollister, in secs. 3, 4, and 9, T. 15 S., R. 8 E., M. D. Cinnabar occurs in serpentine and silica-carbonate rock along the Bradford fault, which thrusts Franciscan over Panoche to the southwest. The workings are caved, but a diagram is given by Forstner (03, p. 132). An incline shaft followed the contact of the silica-carbonate rock with underlying fault gouge for 200 feet. Down the slope to the north, 160 feet vertically below the collar of the shaft, a tunnel was driven southeast for 535 feet, following the same contact. This tunnel was connected with the shaft by a raise. Forstner (03, p. 133) states: ''No ore bodies have been disclosed by this work; however, the serpentine carries some cinnabar throughout.'' Cinnabar is said to have been discovered here in 1859 during construction of the road up Tres Pinos Creek to the New Idria mine. The production is unknown, but the mine is listed as a small producer on the outline geologic map of California showing locations of quicksilver properties (Jenkins 39). The mine has been idle for a number of years.

The *Cannon mine* is located adjacent to and north of the Bradford, along the same belt of silica-carbonate rock, in sec. 4, T. 15 S., R. 8 E., M. D. The workings are caved, but Forstner (03, p. 134) describes them as follows:

> "A drift 130 feet long has been run, with a winze 30 feet deep in the silicified serpentine. At the bottom of the winze is a drift 90 feet long, showing that the serpentine carries some cinnabar, but without disclosing a pay shoot."

The *Butts mine* is located east of Pine Rock in the SW¼ sec. 4, T. 16 S., R. 8 E., M. D. It is 28 miles by road southeast of Hollister. The mine is in brecciated Franciscan sandstone situated in a sliver along the San Benito fault zone. Prior to 1903 a tunnel 300 feet long had been driven, and a shaft 20 feet deep had been sunk (Forstner 03, p. 133). These workings produced a small amount of mercury. Some other workings a quarter of a mile north were opened during World War I. These workings are now caved, but a description is given by Bradley (18, pp. 101-102) as follows:

> "An open cut and tunnel totalling 75 feet, driven some time ago by (Geo.) Kline, in which it is reported that good ore was found, have caved in. A tunnel and open cut totalling 60 feet have been driven above this caved ground and about 20 feet below the outcrop. This has cut diagonally across a chert and sandstone breccia which carries ore for a width of about 18 inches. Cinnabar and metacinnabarite occur in the cementing material of the breccia with a calcite gangue."

The mine has had a small production, but has not been worked in recent years.

The *Lone Star mine* is reported to occur in the Rancho Real de las Aguilas, or McCreary Ranch, 18 miles southeast of Tres Pinos, near Los Muertos Creek. This location is in the main Franciscan area of the San Benito quadrangle. The mine was not seen by the writer, but Bradley (18, p. 107) states:

> "A tunnel said to be 800 feet long has been driven. Rock purporting to come from this mine showed a little cinnabar in altered and iron-stained serpentine, but no ore in commercial amount was reported."

Manganese

The *McCreary Ranch mine* is situated north of Antelope Creek in the Rancho Real de las Aguilas or McCreary Ranch, in the S½ sec. 29, T. 14 S., R. 9 E., M. D. The property is leased to R. R. Stephenson, 548 Glenview, Oakland, and was being developed in the early part of 1943. No ore had been shipped as yet, but some had been removed and stockpiled at the mine. Two open cuts 100 feet apart are situated on different horizons of manganese oxide enclosed in Franciscan chert. The chert in turn occurs as lenses bordered by greenstone, but the main rock in the surrounding area is Franciscan sandstone. The chert strikes N. 35° E., and dips 40° NW. The western cut reveals a lens of high-grade manganese oxide ore enclosed in massive white and pale-green chert cut by quartz veinlets and stained by manganese oxide. The ore is chiefly of the hard, blue-black psilomelane type, minutely botryoidal, and somewhat porous. It is accompanied by soft black oxide. The ore contains red hematite stains and a few patches of cellular silica, although the silica content is comparatively low. The ore sorted out on a stockpile at the mine contains over 50 percent manganese. The eastern cut contains small pockets of ore in a massive manganiferous white chert bed enclosed in thin-bedded white and pale-green chert. The massive chert contains films and seams half an inch thick of manganese oxide. It probably contains some bementite or neotocite (hydrous manganese silicates).

Manganese deposits also occur in San Benito County north of the San Benito quadrangle east of Quien Sabe Valley (Bradley et al. 18, pp. 59-61), just east of the quadrangle on the Hannagan Ranch south of Panoche Valley, and south of the quadrangle on the Chambers Ranch in Bitterwater Valley in a sliver of Franciscan chert in the San Andreas fault zone. A prominent lens of Franciscan chert on Cherry Peak, between Los Muertos Creek and Tres Pinos Creek, contains heavy stains and seams of manganese oxide, although a definite orebody has not been exposed.

Chromite

The *Ingalls prospect* is described by Aubury (06, p. 269) as follows:

> "Tom Ingalls, Emmett P. O., about fifteen years ago performed some development work on a deposit of chromite, in Sec. 36, T. 14 S., R. 7 E., and it is claimed found a quantity of good ore. Since that time no further work has been done."

The writer is uncertain as to the exact location of this prospect, but it is presumably in one of the small serpentine bodies in the Franciscan glaucophane schist belt which occurs in the southeastern part of sec. 36, northeast of "Emmett Station" on the topographic map (now Elkhorn Ranch).

Gold

Prospecting for gold has been carried on in the Pinnacles National Monument, just south of the San Benito quadrangle. Two tunnels, the Chalone and Defiance, were driven 540 and 400 feet, respectively, in sec. 14, T. 17 S., R. 7 E., M. D. (Bradley and Logan 19, p. 638). Gold is said to be a primary constituent of the Miocene rhyolite which occurs at this locality. Bradley and Logan state:

> ". . . assays showed gold values of one to five dollars at several places in the (Chalone) tunnel, but no quantity of ore was found. There appeared no way of distinguishing barren from gold-bearing material."

Copper

The *Copper Mountain Mining Company* carried on exploration for copper just south of the San Benito quadrangle and one mile west of the Pinnacles National Monument in sec. 33, T. 16 S., R. 7 E. Several adits and open cuts were excavated in granite containing iron gossan, copper carbonate stains, and chalcopyrite (Laizure 26, p. 233). It is reported that right and title to the ground have been revoked by the Land Office in view of its position controlling the western entrance to the Pinnacles National Monument.

The *Antelope copper mine* is located one mile east of the San Benito quadrangle, east of Antelope Creek, in sec. 4, T. 15 S., R. 9 E., M. D. It was discovered in 1887, and is now owned by H. V. Underwood et al. of Hollister. The mine is in the main Franciscan area of the quadrangle. It was not visited by the writer, but from the description it is judged to be in Franciscan sandstone impregnated with copper carbonate and iron oxide (Laizure 26, pp. 231-232). Early workings consisted of two inclines 400 feet and 100 feet in length. Later another incline was driven for 200 feet; and a winze 10 feet deep was sunk 100 feet from the mouth. The walls of this working are said to be covered with a thin scale of green chalcanthite, hydrous copper sulphate. No copper has been produced from this mine, so far as known, but early in 1943 attempts were under way to have the deposit developed.

Coal

Coal is said to have been worked north of Emmett (now Elkhorn Ranch) in 1878. According to Irelan (88, p. 486), "About five hundred pounds were shipped to England, and there pronounced good jet. . . .". An incline and two tunnels were driven, but these workings have long since caved. The reported locality as shown to the writer by local inhabitants consists of a bed of impure lignite about 6 inches thick enclosed in clay-shale of the San Benito gravels.

Bentonite

Deposits of a plastic clay resembling bentonite, locally called ''mineral soap,'' have been sporadically mined at two localities along Willow Creek: (1) in the Miocene vent tuff area in sec. 33, T. 15 S., R. 7 E.; (2) in a tuffaceous layer in the Pinnacles formation in the N½ sec. 30, T. 15 S., R. 7 E. These deposits are owned by George Melendy. Small open cuts and a short tunnel have been developed. Some of the material has been mined and shipped in recent years, but the exact production is unknown.

Oil and Gas

The oil-bearing formations of the Coalinga and Kettleman Hills districts occur in two belts in the San Benito quadrangle: the Upper Cretaceous, Eocene, and middle Miocene formations in the Butts Ranch-Vallecitos belt, and the upper Miocene and Pliocene beds in the San Benito-Waltham Canyon belt. Favorable structures for the accumulation of petroleum do not appear to be present, however. Both belts are so strongly folded that the dips are for the most part close to vertical or are overturned. Oil has been obtained to the northwest in the Sargent district, and drilling has been carried on to the southeast in the Vallecitos syncline. Wells have been drilled in Topo Valley, south of the quadrangle, in oil seepages in Miocene sediments, but without success. Local inhabitants have told of gas seepages south of Tres Pinos Creek, in an area in which the Cretaceous and Tertiary sediments of the Butts Ranch syncline are overlapped by the Plio-Pleistocene San Benito gravels. The writer could not verify this reported occurrence, however.

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MINERAL EXHIBIT AND STATISTICS

CURRENT NOTES ON EXHIBITS AND STATISTICS

By Henry H. Symons*

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MUSEUM ACQUISITIONS

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of economic and academic value. It ranks among the first five such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors, as well as tourists and sightseers. In addition to its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the Division of Mines, as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the exhibits are the following:

21112 NEPHRITE JADE. Locality: tideland south of Big Sur, Monterey County, California. Donor: Lawson C. Shaug. March 1943. In case 227.

21113 KYANITE (an aluminum silicate—Al_2SiO_5). Locality: Cope's Bridge, west of Westchester, Pennsylvania. Donor: Geo. R. Cope. January 1943. In case 131.

21114 SCHEELITE coated with a thin film of TUNGSTITE in tactite. Locality: Margarita claim in Sheppard Canyon, Inyo County, California. Donor: Eugene A. Bacchi. January 1943. In case 209.

21115 SCHEELITE in quartz. Locality: Sheep Head claim in Trail Canyon, 18 miles west of Furnace Creek Ranch, Inyo County, California. Donor: Milton L. Knapp. January 1943. In case 209.

21116 TALC. Locality: north end of the Panamints, Inyo County, California. Donor: Death Valley Curly. January 1943. In case 210.

21117 MANGANESE ORE (over 48 percent manganese). Locality: 30 miles south of Winnemucca, Nevada. Donor: William Polkinghorne. February 1943. In case 241.

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* Curator and Statistician, Division of Mines. Manuscript submitted for publication May 14, 1943.

21118 ARSENOPYRITE in limestone. Locality: Property of Pacific Limestone Products Company, in Santa Cruz, California. Donor: Fred W. Johnson. February 1943. In case 109.

21119 CALIFORNIA JADE (IDOCRASE) with GOLD. Locality: Near Happy Camp, Siskiyou County, California. Donor: T. Orchard Lisle. March 1943. In case 616.

21120 WYOMING JADE. Locality: Near Casper, Wyoming. Donor: T. Orchard Lisle. March 1943. In case 616.

21121 CALCITE. Locality: limestone quarry on Rattle Snake Creek, near Auburn, Placer County, California. Donor: T. Orchard Lisle. March 1943. In fluorescence case.

21122 CINNABAR. Locality: Polar Star mine near San Simeon, San Luis Obispo County, California. Donor: E. D. Rogers. April 1943. In case 309.

21123 SILVER (native) and GOLD. Locality: Big Seven mine, Neihart, Montana. Donor: Henry Croff. April 1943. In case 242.

21124 RUBY SILVER. Locality: Big Seven mine, Neihart, Montana. Donor: Henry Croff. April 1943. In case 242.

21125 SILVER-ZINC ore. Locality: Ripple mine, Neihart, Montana. Donor: Henry Croff. April 1943. In case 242.

21126 LEAD-SILVER ore. Locality: Silver Dike mine, Neihart, Montana. Donor: Henry Croff. April 1943. In case 242.

21127 LEAD-ZINC-SILVER ore. Locality: Silver Belt mine, Neihart, Montana. Donor: Henry Croff. April 1943. In case 310.

21128 LEAD-ZINC-SILVER ore. Locality: Ingersoll mine, Neihart, Montana. Donor: Henry Croff. April 1943. In reserve.

21129 SILVER (brittle silver ore). Locality: Ruth Mary mine, Neihart, Montana. Donor: Tony and Carl Faller. April 1943. In case 242.

STATISTICS

The counties of California for some years past have produced more than 50 different mineral substances. Total value of production was estimated at $379,483,000 for 1942.[1]

At present (May 1943) reports from most of the 1942 producers have been received. Data for several substances are now compiled, and are presented herein. Information at hand indicates that there was no commercial production during 1942 of the following: arsenic, bismuth, calcium silicates, fluorspar, mica, nickel, serpentine, shale oil, tin, vanadium, and zircon.

There was a single producer of each of the following: coal, lithia, molybdenum, potash, pyrite, slate, and titanium.

Borates

During the year, there was produced in California a total of 232,833 net tons of borate material, as compared with 278,451 tons for the preceding year. The material shipped during the year included the sodium borates, kernite (rasorite), kramerite from Kern County; also crystallized borax prepared by evaporation of brines at Searles Lake in San Bernardino County and Owens Lake in Inyo County, and a small amount of colemanite from Death Valley, Inyo County.

As the crude ore is not sold as such, but is almost always refined into the borax of commerce before shipping, and since the material varies widely in boric acid content, tonnage has been recalculated on the basis of 40 percent A.B.A. This is approximately the average A.B.A. content of colemanite after calcining, and also of the crystallized borax obtained from evaporation of the lake brines.

Recalculated, the 1942 output totaled 203,716 net tons, valued at $4,929,553, as compared with 224,986 tons worth $4,745,872 for the year 1941. This production came from two properties in Inyo County, two in San Bernardino County, and one in Kern County.

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[1] Symons, Henry H., Review of California mineral production for 1942: California Div. Mines Rept. 39, pp. 106-107, 1943.

Carbon Dioxide

There were two companies producing natural carbon dioxide from wells near Niland, Imperial County, and one from springs near Hopland, Mendocino County, during 1942. The total 1942 production of 193,143 M. cu. ft. of carbon-dioxide gas was converted into 11,921 net tons of dry ice, worth $310,000. In 1941, 138,862 M. cu. ft. of gas made 8,808 tons of dry ice, worth $258,563. The 1942 output was the largest annual yield of commercial carbon dioxide in California.

Cement

During 1942, cement produced in California amounted to 23,306,578 barrels, valued at $35,808,841, f.o.b. plant, of which 12,056,912 barrels came from plants in northern California and 11,249,666 barrels from plants in the southern part of the state. This is the largest annual output in both amount and value ever reported in this state. The 1941 production amounted to 19,531,608 barrels, worth $26,248,694.

Shipments during 1941 were made by 12 plants in 11 counties to the extent of 23,732,414 barrels, valued at $36,964,122 f.o.b. plant, as compared with 19,833,796 barrels, worth $27,219,800 in 1941. During 1942 there were seven operating mills in northern California; one each in Calaveras, Contra Costa, Merced, San Benito, San Mateo, Santa Clara, and Santa Cruz counties, which shipped a total of 12,150,363 barrels of cement; five mills in southern California; two in San Bernardino County; and one each in Kern, Los Angeles, and Riverside counties, which shipped a total of 11,582,051 barrels of cement. There was an average of 2,889 men employed in the mills during the year. The annual capacity of California cement mills, according to the U. S. Bureau of Mines, was 27,540,000 barrels in January 1943, as compared with 26,040,000 barrels for January 1942.

Dolomite

The 1942 output of dolomite in California totaled 142,552 net tons valued at $413,469 and came from two properties in Monterey County and one each in Inyo, Los Angeles, Riverside, San Benito, and Tuolumne counties. In addition, but not included in the above figures, there was a production of dolomite from Tuolumne County that was burnt for lime, and so was included in the lime figures. The 1942 production was the largest annual yield on record in this state. The 1941 production amounted to 22,300 tons, worth $64,595.

The material shipped during the year was utilized for magnesium metal, for steel furnace flux and refractories, stucco dash, terrazzo, kalsomine, poultry grit, artstone, in mineral-wool, and for the manufacture of carbon dioxide.

Gypsum

Shipments of gypsum from California during 1942 amounted to a total of 425,268 net tons, valued at $791,892, and came from five properties in Kern County, and one each in Fresno, Imperial, Monterey, Riverside, and Ventura counties. In addition to the above figures a considerable amount of gypsum came from Alameda County. This was obtained in a chemical process for reducing magnesium salts from salt-works bittern water with lime; it was not included in the gypsum figures as it was used with lime and magnesite. The 1941 output was the largest annual yield both in amount and value and amounted to 432,784 short tons, worth $854,184.

Iron Ore

Iron ore shipments in California during 1942 totaled 99,092 net tons valued at $371,562 and came from three properties in San Bernardino County and one each in Inyo, Shasta, and Trinity counties. The above was the largest annual output in both amount and value ever reported in this state. The 1941 production was concealed under the ''Unapportioned'' item so as not to reveal the output of individual operators, and came from a single property each in Inyo, San Bernardino, and Santa Cruz counties.

The ore mined during the year was hematite from San Bernardino County, some of which went to the stockpile at the new steel plant at Fontana (which started operating in December 1942), and magnetite from Inyo and Shasta counties, which was used mostly in heavy concrete for ballast.

Magnesium Salts

There was an output of magnesium salts in California coming from two properties in San Mateo County, and one each in Imperial and San Diego counties, amounting to 6,260 net tons, valued at $642,680, compared with 6,352 tons, worth $654,372 in 1941. The material from Imperial County was magnesium sulphate; from San Diego County magnesium chloride; from San Mateo County magnesium carbonate, hydroxide, oxide, and basic carbonate. Also coming from Alameda County was a tonnage of magnesium hydroxide. The latter was not included in the above totals as it was used as magnesite and therefore will be included in the figures for that substance.

Salt

There was an output of salt in California of 672,324 net tons, valued at $1,922,991, as compared with 434,237 tons, worth $1,180,929 in 1941. The 1942 yield was the largest in amount and was surpassed in value only by that of 1929. There were 16 operating plants during the year; four in San Bernardino County, three in Alameda County, two in Imperial County, and one each in Inyo, Kern, Los Angeles, Modoc, Monterey, Orange, and San Diego counties.

The average value reported by salt producers in California in 1942 was $2.86 per ton, f.o.b. plant, compared with $2.72 in 1941; $2.79 in 1940; $2.75 in 1939; $2.78 in 1938; $2.82 in 1937; $3.08 in 1936; and $3.36 in 1935.

Most of the salt production in California is obtained by evaporation of water of the Pacific Ocean, plants being located on the shores of San Francisco, Monterey, and San Diego bays, and at Long Beach. Additional amounts are derived from lakes and lake beds in the desert regions (in part, rock salt), mainly in Imperial, Kern, and San Bernardino counties; and from evaporation of alkaline lake water in

Modoc County. A small amount of valuable medicinal salts has been obtained by evaporation of the water of Lake Mono, Mono County, and from a mineral spring in Butte County.

Silica

The 1942 output of silica (quartz and glass sand) in California amounted to a total of 193,174 net tons, valued at $692,762 f.o.b. rail shipping point, and came from three properties in San Bernardino County; two in Alameda County; and one each in Kern, Mariposa, Orange, Riverside, and San Diego counties. The above consisted of 102,015 tons of glass sand, worth $432,341, and 91,159 tons of boulder quartz, worth $260,421, and was the largest output in amount and value ever recorded in this state. The 1941 production consisted of 107,679 tons of glass sand and 29,981 tons of boulder quartz or a total of 137,660 tons, worth $514,266.

As vein quartz and silica sand are both used in glass making and as abrasives, production figures for these materials have been combined. Both varieties of silica are utilized to some extent in firebrick manufacture.

Such forms of silica as quartzite, sandstone, flint, tripoli, diatomaceous earth, and gems (''rock crystal,'' amethyst, and opal), are not included under this heading. Each of these materials has various industrial uses, and so is treated under its own designation.

Soda

The sodium salts produced in California during 1942 included soda ash and trona, from plants at Owens Lake, Inyo County; and soda ash, salt cake, and trona (sesquicarbonate, a double salt of Na_2CO_3 and $NaHCO_3$) from Searles Lake, San Bernardino County. The plant on Dale Lake near Amboy and Searles Lake, San Bernardino County, made shipments of salt cake in 1942. There were no shipments of salt cake (sulphate) from Carrizo Plains, San Luis Obispo County.

Shipments were made in 1942 amounting to a total of 267,723 net tons valued at $3,125,078, as compared with 179,210 tons worth $2,028,718 in 1941. The 1942 output was the largest annual yield as to amount and value and consisted of 145,957 tons of trona and soda ash worth $2,257,660 and 121,766 tons of salt cake worth $867,418.

The soda ash was used mainly in the manufacture of soap, glass, paper, oil refining, sugar refining, and chemicals; and the trona for metallurgical purposes. The salt cake or sodium sulphate was used in the manufacture of paper, glass, and in chemicals.

Talc and Soapstone

The total production of talc and soapstone in California during 1942 amounted to 47,782 net tons valued at $545,509, as compared with 47,935 tons worth $525,396 in 1941. The 1942 output had the largest annual value of any year on record in this state, although the 1941 output slightly passed it in amount. The 1942 output of high-grade talc came from eight properties in Inyo County and three in San Bernardino County; and the soapstone from a single property in El Dorado County.

LABORATORY

ADDITIONS TO BULLETIN 113

By George L. Gary*

Since 1866 many lists have been published showing localities of California minerals. The last one, *Minerals of California,* by Adolf Pabst, was published in 1938 by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly California Journal of Mines and Geology new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Following is a current addition to Bulletin 113:

123. **Piedmontite** has been reported from Whitewater, near Palm Springs, Riverside County.

Corrections will also be noted, as well as additions, when called to our attention.

LITHIUM

By George L. Gary*

PHYSICAL PROPERTIES

Spodumene ($LiAlSi_2O_6$), lepidolite ($LiKAl_2F_2Si_3O_9$), and amblygonite ($LiAlFPO_4$) are the principal commercial lithium minerals. Their physical properties are as follows:

Name	Color	Luster	Hardness	Gravity
Spodumene	Greenish-white	Vitreous	6½–7	3.13–3.20
Lepidolite	Rose-lilac	Pearly	2½–4	2.80–3.30
Amblygonite	White	Vitreous	6	3.01–3.09

TESTS

As fusible lithium minerals color the flame a bright crimson, the flame-test method generally is used to detect the presence of lithium in minerals and compounds. The crimson color of the lithium flame is not as persistent as that of strontium. A few drops of barium chloride added to a lithium salt in solution and tested in a flame give, first, the crimson of lithium, then the green of barium, and finally, if strontium is present, the red of strontium. Lithium minerals do not become alkaline upon ignition, as do the strontium minerals. Powdered gypsum is added to the silicates before testing.

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OCCURRENCE

Lithium minerals usually are found in pegmatites; lithium is also present in brines, springs, sea water, plant remains and meteorites. In past years lepidolite and amblygonite have been produced in quanities at the Stewart mine at Pala, San Diego County, California. Spodumene, lepidolite, and amblygonite are found in Inyo, Riverside, and San Diego Counties, California (Pabst, A. 38). Crude lithium-sodium phosphate is recovered in substantial quantities as a by-product in the soda operations from Searles Lake, San Bernardino County, California. The crude brines contain as much as 0.032 percent LiCl (Teeple, J. E. 29, p. 18).

PREPARATION

Mining methods are very simple. The crystals (as of spodumene) or masses (as of lepidolite and amblygonite) are handpicked from the broken pegmatite rock. Most of the lepidolite mined and much of the amblygonite occur in solid masses many feet thick and are simply broken down to a size convenient for handling and shipping. No unusual preparation is required before shipment, although pieces of lepidolite containing much quartz and feldspar must be rejected. Where the mineral is to be used directly, as in glass manufacture, all iron minerals must be removed. Where the spodumene is covered with a soft claylike material, this must first be broken off, because it contains almost no lithium. Spodumene ores have been concentrated successfully by froth flotation (Norman and Gieseke 40).

USES

Lithium and its minerals and compounds have many and varied uses in industry. The more important are in the glass, ceramic, chemical, air-conditioning, and metallurgical industries and less extensively in the electrical, pharmaceutical, and optical industries (Houk, L. G. 42; Schaller, W. T. 37, p. 427).

MARKETING

The greater part of lithium-ore production never enters the open market. The chemical manufacturer owns his own mines, the glass manufacturer contracts for his needs, and additional demands are restricted and intermittent. Independent mining operations, therefore, are small and sporadic, and small operators just coming into production find it difficult to guarantee a definite tonnage and quality of ore, yet this they must do to obtain an assured market. Virtually the only method for prospective producers to learn what they can get for their ore is by direct negotiation with buyers. Trade-journal quotations for the various ores are nominal values based upon previous sales of all grades. Price quotations from the Engineering and Mining Journal, March 18, 1943, were as follows:

Spodumene—Per unit Li_2O contained, $5 @ $6 on 6 percent grade, carload lots, North Carolina. Nominal.

Lepidolite—Per ton, $24 @ $25 for ordinary grades, lump, f.o.b. mine.

Amblygonite—Per ton, f.o.b. mines, 8 @ 9 percent Li_2O, $40 @ $50.

Lithium—Per lb., 98 @ 99 percent, 100-lb. lots, $15.

POSSIBLE BUYERS

Associated Metals & Mineral Corporation---40 Rector Street, New York, N. Y.
Bergstrom Trading Company, Inc.----------Woolworth Building, New York, N. Y.
Consolidated Feldspar Corporation--------Trenton, New Jersey
Corning Glass Works--------------------Corning, New York
Foote Mineral Company-----------------16th & Summer Streets, Philadelphia, Pennsylvania
Harshaw Chemical Company--------------1945 East 97th Street, Cleveland, Ohio
E. J. Lavino & Company-----------------1528 Walnut Street, Philadelphia, Pennsylvania
Maywood Chemical Company-------------Maywood, New Jersey
R. T. Vanderbilt Company---------------230 Park Avenue, New York, N. Y.
Varlacoid Chemical Company-------------116 Broad Street, New York, N. Y.

REFERENCES

Some of the works listed below give a short bibliography. Books, annuals, and periodicals on lithium may be consulted in the library of the California State Division of Mines where specimens of ore may also be seen.

Houk, Lawrence G.

42 Marketing lithium minerals: U. S. Bur. Mines Inf. Circ. 7225, 14 pp., December 1942.

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38 Minerals of California: California Div. Mines Bull. 113, 344 pp., 1938.

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37 Lithium minerals. Industrial minerals and rocks (nonmetallics other than fuels) (Seeley W. Mudd Memorial Series), pp. 427-432, Am. Inst. Min. Met. Eng., 1937.

Teeple, John E.

29 The industrial development of Searles Lake brines, with equilibrium data: Am. Chem. Soc. Mon. Ser., no. 49, 182 pp., 1929.

COMMERCIAL MINERALS OF CALIFORNIA

(Series 1943)

QUARTZ

Compiled by W. B. Winston, Laboratory Assistant

Properties. Quartz, SiO_2, is essentially silica or silicon dioxide. It occurs in many different forms. It does not ordinarily show cleavage and most varieties break with a marked conchoidal fracture. It is colorless when pure but found in every color. The luster is vitreous and the mineral may be transparent, translucent or opaque. It has a hardness of 7 and is very resistant. The purest quartz (rock crystal) has a specific gravity of 2.69, other varieties range from 2.5 to 2.8, the mean specific gravity being 2.65 which is that given in the texts. It has one of the highest melting points of all common minerals, 1470° C. One of the outstanding properties of quartz minerals is their chemical and physical stability. It crystallizes in the rhombohedral system generally in 6 sided (hexagonal) prisms horizontally striated (growth lines) and terminated at each end by 6 sided pyramids. The crystals are often twisted and greatly distorted. They may occur in right- and left-handed crystals; a phenomenon due to a peculiar arrangement of the atoms of which the crystals are built up. This condition has its effect on the optical properties. Twinning in quartz crystals is common. Contact twins are those in which two crystals are in contact one with another, and penetrative twins are those in which two individual crystals are so intergrown that they penetrate one another. Quartz is uniaxial and optically positive. Its mean index of refraction 1.55, its double refraction 0.009, and its dispersion 0.013 are all low. Right-handed crystals rotate the plane of polarization to the right, left-handed crystals to the left. Quartz is the best known example of minerals exhibiting circular polarization; that is, which rotates the plane of polarization of light. Quartz possesses strong piezoelectric properties, which is their capacity for developing electrical charges under pressure and changing dimensions when an electrical charge is applied to them. It also possesses strong pyroelectric properties.

The common form of quartz includes practically all sand, standstone, quartzite, and massive crystalline or vein quartz. Quartz holds a rather prominent place among gem stones, due primarily to extensive use of amethyst and citrine and also rock crystal, and because it is found in great profusion and variety of colors, textures, patterns, and combinations. There is, therefore, a long list of names applied to varieties and subvarieties, of which more than 200 have been listed. The varieties of quartz may be grouped into the following three classes: Crystalline varieties, vitreous, crystallized or crystalline, and more or less transparent. Cryptocrystalline varieties, compact and homogeneous, with a crystalline structure which may be observed with the microscope. Clastic varieties, or those which are made up of fragments of quartz, usually cemented into a coherent mass. These include sand and gravel and the rocks sandstone and quartzite.

The CRYSTALLINE FORMS of quartz include ROCK CRYSTAL which is pure transparent and water-clear quartz, usually but not always well crystallized. AMETHYST is a transparent variety of quartz which provides stones of the finest violet color and various shades of purple. It is usually well crystallized. It consists of alternate layers of right- and left-handed quartz, shows Airy's spiral, and breaks with a rippled fracture instead of conchoidal fracture most characteristic of quartz. SMOKY QUARTZ has the physical and chemical properties of clear rock crystal and their crystal forms are identical. It is characterized by a smoky-yellow to dark smoky-brown color due, it is thought, to colorless crystals having been exposed for long periods of time to radium emanations from surrounding rock. CITRINE is a light golden-yellow or reddish-yellow variety which probably owes its color to a slight trace of ferric iron. ROSE QUARTZ is rose-red or pinkish, the color being attributed to the inclusions of a small amount of the salts of titanium or manganese. It is commonly massive and is never found as crystals bounded by faces. MILKY QUARTZ is a transparent milk-white and nearly opaque massive variety very widespread in occurrence. The color is due to vast numbers of cavities containing water or liquefied carbon dioxide, which greatly impairs the transparency of the crystals. SAGENITE is a form inclosing hairlike crystals of rutile or other minerals, giving a net-like appearance to the stone, usually named from the included mineral, as Rutilated Quartz or Tourmalinated Quartz, etc. AVENTURINE is a variety that contains inclusions in the form of scales of some bright mineral as mica or flakes of hematite presenting a spangled appearance when turned in the light. The quartz base may be brown, red, yellow or black, rarely bluish or green. In some unusual quartz types pauses in growth is sometimes shown by cloudy ghost-like images, which suggest 'phantom' forms of earlier crystal growths.

CRYPTOCRYSTALLINE FORMS of quartz, or masses which appear to the unaided eye to be amorphous, include CHALCEDONY, a variety of quartz with a waxy or greasy luster and somewhat splintery fracture, identical with crystalline quartz in chemical composition. Either transparent or translucent occurring in botryoidal, reniform or stalactitic masses. It is composed of microscopic fibers which are optically biaxial. The refractive index and fusing also differ from those of quartz. It is always of secondary origin. There are several forms of chalcedony, all in a variety of dull colors. Chalcedony proper is cream- or milky-colored, and faintly banded. CARNELIAN or SARD is a clear red chalcedony, pale to deep in shade. CHRYSOPRASE is a translucent variety with a leek- or apple-green color in varying shades, due to nickel oxide. HELIOTROPE or BLOODSTONE is essentially a PLASMA. It is a feebly translucent bright green to leek-green chalcedony with small spots of blood-red jasper. The green color is due to chlorite, and possibly ferrous salts; the red to hematite. AGATE is a variegated chalcedony having definite color, pattern, layers, bands, scenes, or markings of some sort. The colored varieties carry a small amount of metallic salts or oxides, usually iron or manganese and, more rarely, nickel, chromium and copper. The presence of a colloidal solution, with the silica so finely divided as to form a silica gel, is the most recent explanation of the origin of agate. Moss agate is a variety in which the variation in color is due to visible impurities, often of manganese oxide in moss-like patterns. Wood that has been petrified by replacement by clouded agate is known as silicified or agatized wood. ONYX is a layered chalcedony, with layers arranged in parallel planes, hence its use for cameos. FLINT is an opaque granular cryptocrystalline variety of quartz usually presenting various dull colors due, it is thought, to organic material. It is brittle, and is composed of an intimate mixture of quartz and opal. CHERT is a compact massive rock similar in most properties to flint, but usually light in color. It is considered to have quite a different mode of origin than flint. JASPER is a granular cryptocrystalline quartz, usually colored red from hematite inclusions. It includes in a general way, nearly all varieties of impure, opaque colored cryptocrystalline quartz. Under the microscope it is essentially a very fibrous quartz—a characteristic in which it differs from all other varieties. The members of this group are very numerous, more than seventy different varieties being listed. The color may be red, yellow, brown, green, bluish or black, due to different impurities, as clay, iron, or organic matter. The usual origin of jasper is in a colloidal solution of silica gel.

CLASTIC VARIETIES such as sand and gravel are unconsolidated aggregates of highly siliceous, usually quartzose grains from the size of microscopic particles to boulders. Sands vary greatly according to origin. Sandstone is a rock composed of grains of sand solidified together by some cementing material as silica, iron oxide, calcium carbonate, or clay. QUARTZITE is a metamorphosed sandstone. The cementing material is secondary quartz, giving the stone the appearance of massive quartz. TRIPOLI is a white, finely granular porous form of chalcedonic quartz. PSEUDOMORPHOUS, or 'false forms,' of quartz include the forms quartz has taken through alteration or replacement of crystals of other species—commonly calcite, barite, fluorite and siderite. Silicified wood is one form. TIGER-EYE is a good example of a quartz pseudomorph. It is an asbestos mineral (crocidolite) which has been completely silicified and the original fibers altered to yellow oxide of iron—limonite. In the AMORPHOUS state there are two forms of silica, opal and diatomite; they are not of the quartz family. For more complete description of quartz minerals consult Dana's 'System of Mineralogy.' Also Ref. 4e, 2 and 3.

Tests. Quartz is infusible even on the thinnest edges. When fused with equal volume of sodium carbonate, effervesces and gives a colorless glass; unacted upon by salt of phosphorous. Soluble only in hydrofluoric acid.

In the field, quartz is one of the easiest minerals to determine by sight identification. It may be distinguished by its hardness which is such that it will scratch glass easily, but the mineral can not be scratched with a knife, the steel of which leaves a metallic mark on the stone. By its lack of cleavage, general glass-like appearance, and pronounced shell-like fracture. Most of the imperfections in quartz crystals, as cracks, ghosts, veils, phantoms, needles, and bubbles, can be seen with the unaided eye except optical twinning which is one of the commonest and most serious defects. In twin crystals the individuals have intergrown according to a definite law, and some types of twinning can be observed only in polarized light under the microscope. A laboratory test is required to determine the piezoelectric properties of quartz.

Occurrence. Quartz occurs in nearly every type of rock, igneous, sedimentary, or metamorphic, and is found in formations of all geological ages. Next to the feldspar group it is the most abundant mineral in the earth's crust, free quartz composing fully 12 per cent of the entire lithosphere; and it appears in a greater number of varieties and modes of occurrence than any other mineral. Quartz occurs as a primary and essential constituent of igneous rocks, such as granite, quartz-porphyry, and rhyolite. In pegmatite graphic granite and granophyre it often forms a regular intergrowth with feldspar. It is also a common constituent as regular grains in many gneisses and crystalline schists. By the weathering of silicates silica passes into solution, and quartz is deposited as a secondary product in the cavities of basic igneous rocks. Vein quartz represents the end products of the intrusion and solidification of acidic plutonic igneous rocks, deposition taking place in fractures and fissures in the earth's crust; extensive veins of quartz are also frequent in schistose rocks. Quartz forms the bulk of sands and sandstones. Through weathering of the granites the quartz grains are released, and when these grains are once more cemented by a deposit of secondary quartz, sandstone and quartzite result. Flint is usually concretinary in form, occurring as pebbles and boulders in other rocks, but sometimes in thick beds. Chert may occur in thick beds, usually brecciated. Among the gem minerals, rock crystal is one of the most abundant. It is found principally in Brazil, Japan, Madagascar, and (small crystals) in New York and Arkansas. It occurs in association with pegmatite, in clefts and crevices in sandstone, and in cavities of limestone, etc. Large cavities have yielded hundreds of tons of crystals, some over 6 ft. long and 2 ft. in diameter, weighing over two tons. Granite rocks and granite pegmatites are favorable places for the formation of large single quartz crystals and groups of crystals. Rock crystals of small dimensions are found in great profusion throughout the world, there is hardly a state in the Union in which fine crystals have not been found. Smoky quartz crystals are most likely to be found associated wth granites and pegmatite dikes. Amethyst occurs usually as druses lining the inner walls of cavities or veins in granite or other igneous rocks, and sometimes lining hollow agate geodes.

All quartz materials, except perhaps quartz crystals of optical grade, are abundantly available in many parts of the United States. In California deposits of vein quartz are plentiful, and many forms of silica occur in commercial quantities, as sand, quartz, quartzite, sandstone and chalcedony. And many of the quartz gem stones are found in the State, such as rose quartz, smoky quartz, and amethyst. Good rock crystal in fine large aggregates has been found in many of the gold mines in Calaveras County, and some good crystal has been reported from 14 counties. For a more complete description of quartz occurrence consult Ref. 4a, c and e. Also 3.

Preparation. Nearly all common quartz is mined from open cuts, quarries, or pit excavations, stripping and excavating methods depending upon the character of deposit and size of workings. The product is usually hauled or shipped to a central grinding plant. At the time of loading the quarried quartz is hand-sorted to eliminate waste rock, and it is also hand-cobbed to some extent. Quartz from pegmatite dikes is usually a by-product in mining feldspar or mica, from which it breaks easily. Preparation at the mine before shipment depends partly on the ultimate use of the product. If going to a pulverizing plant no other preparation or treatment is required than breaking to convenient size for handling. For some special purposes, as acid-tower packing it may be broken to the required size by hand. Metallurgical quartz for flux requires no other preparation than coarse crushing. Abrasive quartz for sandpaper and similar uses is ordinarily prepared by stage crushing and by screening between stages. Crushing and screening is dry, and dry grinding is almost universal. Much of the quartz consumed in the various industries needs to be ground until finely divided. It is nearly always pulverized in tube or pebble mills. The fine pulverizing of rock quartz is sometimes preceded by calcination to make pulverizing easier. Sand is never so treated. Calcining applies especially to quartz used in ceramic bodies. For this purpose the material is ground to pass a 140-mesh screen, and for paint, polishes, and fillers, etc., a 200- or 325-mesh screen. Crystal quartz of the gem varieties requires many different forms of preparation according to intended use. For detailed discussion of the mining and preparation of silica and sand see Ref. 4a, also c and d. For quartz of the gem varieties consult Ref. 2, and also 4e.

Uses. The factors that determine the adaptability of certain quartz material for a specific use are physical, chemical, and optical. Quartz is extensively used in pottery manufacture to diminish shrinkage of ware in burning. It is also used in the manufacture of wood filler, paints, scouring soap, sandpaper, filters, and tooth powders. Blocks of massive quartz and quartzite are employed as a filler for acid towers, and tube-mill linings. Quartz is also used as a flux in copper smelting and in the manufacture of silicon and ferrosilicon. Much chemical ware is now made of fused quartz. As quartzite, sandstone, and other rock forms, it is used as a building stone and for paving purposes. Many varieties of quartz are used in the cheaper grades of jewelry, but excepting the better grades of amethyst, most quartz material is worth little more than the cost of cutting. Clear rock crystal, however, is used for innumerable ornamental objects such as vases, art figures, crystal balls, etc., and is often cut into beads and fancy shapes and fashioned to resemble the diamond. Rock crystal also furnishes the material for certain glasses and fused silica ware. Selected crystals are employed in optical instruments, for scientific and military use, chiefly as wedges for microscopic work as spectrographic prisms, and for piezoelectric plates which serve to control wave lengths in radio broadcasting. Miscellaneous uses of military interest are in range finders, in instruments used for measuring pressures or detonation in gun barrels or airplane engines, in depth-sounding and direction-finding apparatus, and for sundry precision instruments, including chronometers, seismographs, periscopes, gun sights, and polariscopes. Rock crystal for optical or piezoelectric use must be chemically absolutely pure, and physically of clear optical quality entirely free of color, air and gas bubbles, specks, cracks, seams, feathers, clouds, phantoms, or any other physical flaws. The crystals must be single and optically right or left handed but not twinned. Piezoelectric quartz should also show growth lines on at least two side faces to be able to determine the direction in which the optical axis lies. For radio purposes smoky quartz crystals of a yellow or light smoky color can be used. The minimum size of crystals acceptable by the U. S. government is one inch diameter to two inches in length or about one-quarter of a pound in weight; sizes between 1 and 4 pounds are preferred. Thirty per cent of such crystals must be free of flaws. Although a premium is paid for quartz with crystal faces, unfaced material is also usable. For detailed discussion of the uses of quartz material consult Ref. 4b, also a, c, d, e, and f. Also 1 and 2.

Marketing. Prices quoted by U. S. government agencies, May 1943, on piezoelectric material was \$36 a pound for best quality crystals in large sizes, but the average price, since the best grades are very scarce, range from \$1 to \$10 per pound. Quotations Eng. and Min. Jour., April 1943, were as follows: Quartz Rock crystals—for fusing, all sizes \$100 @ \$150 per ton. Prisms for piezoelectric and optical use command a substantial premium. Silica per ton, water ground and floated, in bags, f.o.b. Illinois: 325 mesh, \$21 @ \$40 for 92 to 99½ per cent grades. Dry ground air-floated, 325 mesh, 92 @ 99½ per cent silica $18 @ $30. Glass sand f.o.b. producing plant, $1.25 @ $5 per ton.

Possible Buyers. In the following a few names of possible buyers are given. A more complete list will be furnished by the State Division of Mines. Buyers of high-grade quartz crystals of radio and optical grade in California are: Pacific Radio Crystal Co., 1035 Post St., San Francisco; Karr Engineering Co., Palo Alto; Heintz and Kaufman, Ltd., San Bruno; Electric Products Corp., 950 30th St., Oakland. Silica: Industrial Minerals and Chemical Co., 6th and Gilman St., Berkeley; Kennedy Minerals Co., 2550 East Olympic Blvd., Los Angeles.

The U. S. government will buy quartz crystals of optical and piezoelectric grade as given. Quartz crystals should be sent to W. A. Roche, Quartz Testing Laboratory, U. S. Bureau of Standards, Washington, D. C. If the material sent to the Bureau of Standards is for sale, notice should be sent to R. Gordon Taylor, Miscellaneous Minerals Division, WPB, Washington, D. C., stating that the samples have been sent for testing and grading and that they are offered for sale. Those crystals found acceptable will be paid for by the Metals Reserve Company.

If the samples are sent to the Bureau of Standards merely for testing, H. M. Bannerman, U. S. Geological Survey, Washington, D. C., should be notified in order that they may be inspected by the USGS. If the material submitted does not grade up to specifications and is not marketable, it will be rejected, but will be returned to the shipper if so requested. The procurement Div. of the U. S. Navy Purchasing Office, 315 Montgomery St., San Francisco, will also purchase quartz crystals.

Selected References. Much has been written on quartz minerals and silica material. For more complete descriptions, the following references have been selected; some of these works give an extensive bibliography and most of them are easily obtainable. Books, annuals, and periodicals, as well as mimeographed papers on quartz, may be consulted or obtained at the State Division of Mines, where specimens of rock and gem stones may also be seen.

1. Industrial Minerals and Rocks. Various authors. Quartz, pp. 517-522. Also chapters on Abrasives, Dimension Stone, Granules, and Special Sands, etc., bibliographies. Am. Inst. Min. and Met. Eng., N. Y. 1937.
2. Kraus, E. H. and Slawson, C. B. Gems and Gem Materials, McGraw-Hill Book Co., 1939.
3. Pabst, Adolf. Minerals of California, Calif. State. Div. of Mines, Bull. 113, 1938.
4. U. S. Bur. of Mines (a) W. H. Weigel. Technology and uses of silica and sand, Bull. 266, 1927. (b) R. M. Santmyers. Quartz and Silica, Part I, General Summary, I. C. 6472, 1931. (c) Part II, Quartz, Quartzite, and Sandstone, I. C. 6473, 1943. (d) Part III, Sand and Misc., silicas, I. C. 6474, 1931. (e) I. Aikens, Quartz Gem Stones, I. C. 6561, 1932. (f) Minerals Yearbook, Review of 1940.

LIBRARY

LIBRARY REPORT

By Henry G. Hubbard*

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INTRODUCTION

The library of the Division of Mines contains more than 6,000 selected volumes on mines, mining, and allied subjects. It is also the repository for reports and bulletins of technical departments of Federal and State governments and educational institutions both domestic and foreign. Current copies of newspapers published in the mining centers of the State are also available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY AND UNITED STATES BUREAU OF MINES

The library of the Division of Mines has available for public reference the following publications of the United States Geological Survey: Annual Reports, Monographs, Professional Papers, Bulletins, Water-Supply Papers, Mineral Resources, Folios of the Geologic Atlas of the United States (broken file), Maps with Descriptive Text (broken file), Administrative Publications (broken file); and the following publications of the United States Bureau of Mines: Bulletins, Technical Papers, Economic Papers (broken file), Mineral Resources of the United States, Monographs (broken file), Reports of Investigations, Information Circulars.

Reports on California recently received from the Survey and Bureau of Mines include:

United States Geological Survey

Bulletins

931-B	Some Quicksilver Prospects in Adjacent Parts of California, Nevada and Oregon.
931-E	Tungsten Deposits in the Sierra Nevada near Bishop, California.
931-Q	Quicksilver and Antimony Deposits of the Stayton District near Hollister, California.

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* Librarian, Division of Mines. Manuscript submitted for publication May 14, 1943.

931-S	Manganese Deposits in the Paymaster Mining District, Imperial County, Calif. 1942.
932-A-B-C-D	Geophysical Abstracts January-December 1941.
936-D	Chromite and Quicksilver Deposits of the Del Puerto area, Stanislaus County, California, 1942.
936-F	Quicksilver Deposits of the Parkfield District, California, 1942.
938	Bibilography of North American Geology for 1940 and 1941.
939-A-B	Geophysical Abstracts, January-June, 1942.

Water-Supply Papers

930	Surface Water Supply of the Great Basin (California, etc.) 1941.
931	Surface Water Supply of Pacific Slope Basins in California, 1941.

Topographic Maps

Eureka Quadrangle, Humboldt County, California, 1942.
Point Loma Quadrangle, San Diego County, California, 1942.
Reprints (without revision): Cuyamaca; McFarland; Triunfo Pass; and Watts quadrangles.

Professional Papers

197-E	Some Standard Thermal Dehydration Curves of Minerals, 1943.
197-F	The Action of some Aqueous Solutions on Clays of the Montmorillonite Group. 1943.

United States Bureau of Mines

Bulletins

419	Metal Mining Practice by Jackson & Hedges, 1940.
421	The Joseph A. Holmes Safety Association and its Awards, 1940.
423	Mechanical Shoveling in Underground Metal Mines, 1940.
424	Mineral Industries Survey of the United States—(Part II) Tuolumne and Mariposa Counties, California. 1940. (Continues Mother Lode from Part I in Bulletin 413.)

Technical Papers

608	Safety Factors in Construction and Ventilation, Wawona Vehicular Tunnel, Yosemite Park, California, 1940.
609	Bentonite: Its Properties, Mining, Preparation, and Utilization. 1940.

Reports of Investigations

3673	Stemming in Metal Mines. Progress Report 5. Comparison of Dust and Gases Produced from Different Blasting Charges. 1942.
3678	Use of Wetting Agents in Reducing Dust Produced by Wet Drilling in Basalt. 1943.
3684	Manganese Investigations 20. Ore-Dressing Studies of Eastern Manganese Ores. 1943.

Information Circulars

7202	Marketing Silica (Quartz, Tripoli, Diatomite, etc). 1942.
7222	Use of Diesel Locomotives in Tunnels. 1942.
7224	Directions for Laboratory Mineral Sizing. 1942.
7225	Marketing Lithium Minerals. 1942.
7226	High-Grade Dolomite Deposits in the United States. 1942.
7227	Dolomite-Base Refractories. 1942.
7228	Some Haulage and Hoisting Hazards in Western Mines. 1942.
7233	Monazite Sand by Lawrence G. Houk. 1943.
7234	Marketing Kyanite and Allied Minerals. 1943.

PUBLICATIONS OF STATE SURVEYS

A broken file of mining and geological publications, issued by the organizations listed below, may be consulted in the library of the Division of Mines.

Alabama Geological Survey, University.
Alaska (Territorial Commissioner of Mines), Juneau.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Indiana Division of Geology, Indianapolis.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.

Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Geological Survey and Water Resources, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
New York Science Division, Albany.
North Carolina Geological and Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological and Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

PUBLICATIONS OF FOREIGN GOVERNMENTS

Publications of the following foreign governments are received and current issues may be consulted in the library. Earlier issues of foreign-language publications have been loaned to the California Academy of Sciences in Golden Gate Park, because of the limited storage space at the Division's offices in the Ferry Building. They may, however, be consulted at the Academy.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum of Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia Geological Survey, Perth.

PUBLICATIONS OF FOREIGN AND DOMESTIC SOCIETIES AND EDUCATIONAL INSTITUTIONS

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.

Franklin Institute of the State of Pennsylvania, Lancaster.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Missouri School of Mines and Metallurgy, Rolla.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economic Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Acadamy of Sciences, Los Angeles.
Stanford University, Palo Alto, California.
University of California Publications in Engineering, Geography, and Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

CURRENT MAGAZINES

Current issues of the technical magazines listed below are on file in the reading room of the library, and may be consulted.

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Chemical Industries, New York City.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Desert, El Centro, California.
Engineering and Mining Journal, New York City.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining News, Spokane, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Outdoor Georgia, Atlanta.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

NEWSPAPERS

Current issues of the following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles. California.
Mariposa Gazette, Mariposa, California.
Mining Press, Reno, Nevada.
Mohave Miner, Kingman, Arizona.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Placer Herald, Auburn, California.
Placerville Times, Placerville, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

NEW BOOKS

Recent accessions to the library are the following books:

Dampier, Sir William Cecil, A history of science and its relations with philosophy and religion, 3d ed., 574 pp., New York, MacMillan Co., 1942. (John Hays Hammond Public Mining Library.)

DeGolyer, E. (editor), Elements of the Petroleum Industry, Am. Inst. Min. Met. Eng., Seeley W. Mudd Series, 519 pp., 1940. (John Hays Hammond Public Mining Library.)

Fitzhugh, Edward F., Jr., Treasures in the earth, 130 pp., Caldwell, Idaho, The Caxton Printers, Ltd., 1936. (John Hays Hammond Public Mining Library.)

Gustafson, A. F., Ries, H., Guise, C. H. and **Hamilton, W. J., Jr.,** Conservation in the United States, 445 pp., Ithaca, New York, Comstock Publishing Co., Inc., 1940. (F. W. Bradley Memorial Book Fund.)

Holmes, Harry N., Strategic materials and national strength, 106 pp., New York, MacMillan Co., 1942. (John Hays Hammond Public Mining Library.)

Lahee, Frederic H., Field geology, 4th ed., 853 pp., New York, McGraw-Hill Book Co., 1941. (John Hays Hammond Public Mining Library.)

Lawrie, J. P., Methane, its production and utilization, 66 pp., London, Chapman and Hall, Ltd., 1940. (John Hays Hammond Public Mining Library.)

Meinzer, Oscar E. (editor), Physics of the earth—IX—hydrology, 712 pp., New York, McGraw-Hill Book Co., 1942. (John Hays Hammond Public Mining Library.)

Newton, Joseph and **Wilson, Curtis L.,** Metallurgy of copper, 518 pp., New York, John Wiley & Sons, Inc., 1942. (John Hays Hammond Public Mining Library.)

Paine, Paul, Oil property valuation, 204 pp., New York, John Wiley & Sons, Inc., 1942. (John Hays Hammond Public Mining Library.)

von Bernewitz, M. W. (revised by Harry C. Chellson), Handbook for prospectors and operators of small mines, 4th ed., 547 pp., New York, McGraw-Hill Book Co., 1943. (John Hays Hammond Public Mining Library.)

SERVICES OF THE DIVISION OF MINES

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January 1922, and continued until March 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September 1923. For the same reason, beginning with the January 1924 issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January 1933 chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

TYPES OF REPORTS

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire State of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

Reports of District Mining Engineers

In 1919-1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the locations of the branch offices are shown on the frontispiece outline map of the State.

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

Special Articles

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Division, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

MAIL AND FILES

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

COMMERCIAL MINERAL NOTES

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial

minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

Publications of the Division of Mines

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-three years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for advancing the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

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WALTER W. BRADLEY State Mineralogist

Vol. 39 JULY 1943 No. 3

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXIX

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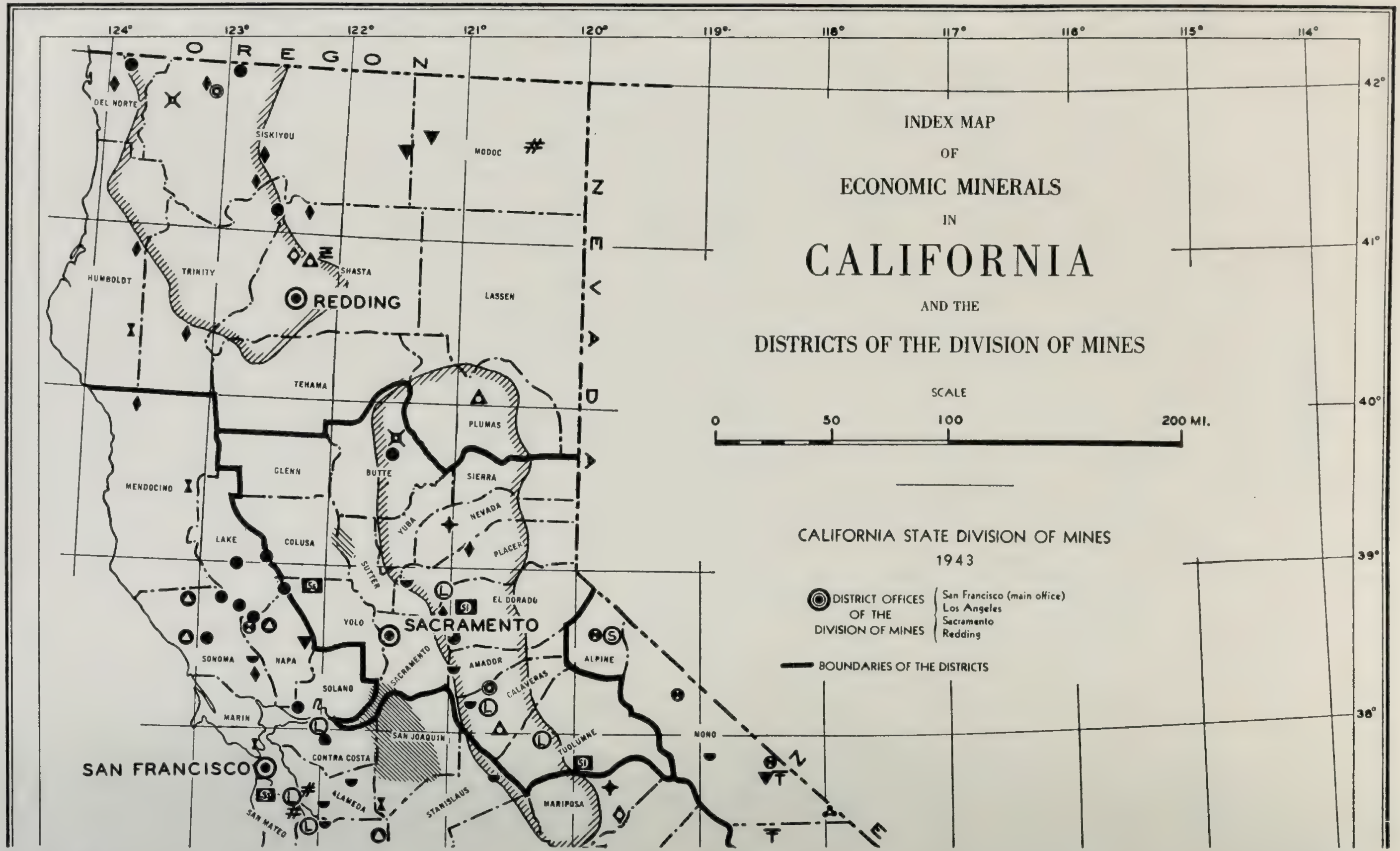
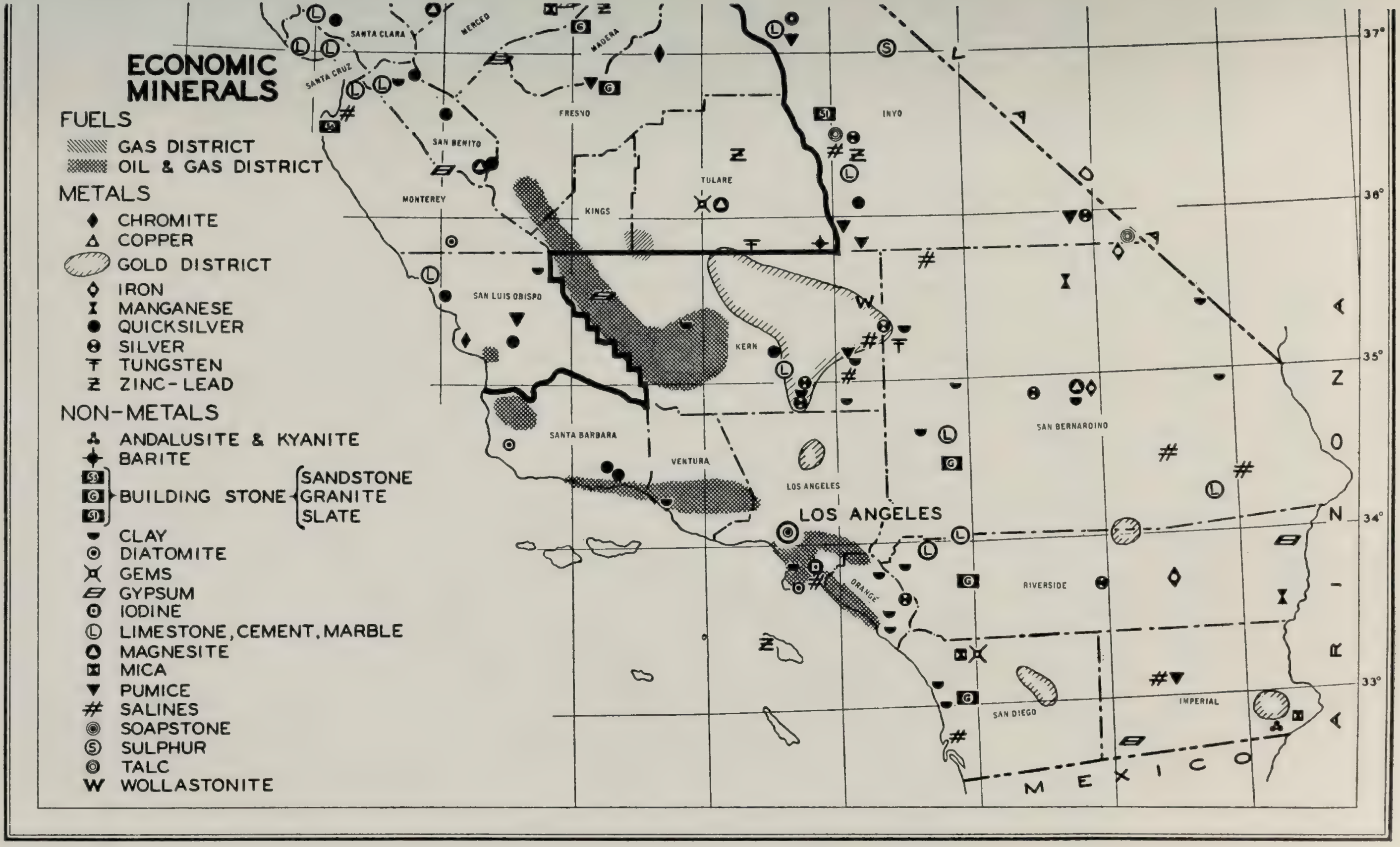


INDEX MAP
OF
ECONOMIC MINERALS
IN
CALIFORNIA
AND THE
DISTRICTS OF THE DIVISION OF MINES

CALIFORNIA STATE DIVISION OF MINES
1943

SCALE
0
50
100
200 MI.
DISTRICT OFFICES OF THE DIVISION OF MINES
San Francisco (main office)
Los Angeles
Sacramento
Redding
BOUNDARIES OF THE DISTRICTS
124°
123°
122°
121°
120°
119°
118°
117°
116°
115°
114°
42°
41°
40°
39°
38°
OREGON
NEVADA
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
REDDING
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
LAKE
COLUSA
YUBA
NEVADA
PLACER
SUTTER
EL DORADO
YOLO
SACRAMENTO
ALPINE
SONOMA
NAPA
AMADOR
SOLANO
SACRAMENTO
CALAVERAS
MARIN
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
CONTRA COSTA
ALAMEDA
SAN MATEO
STANISLAUS
MARIPOSA


ECONOMIC MINERALS
FUELS
▨ GAS DISTRICT
▨ OIL & GAS DISTRICT
METALS
◆ CHROMITE
△ COPPER
GOLD DISTRICT
◇ IRON
MANGANESE
● QUICKSILVER
SILVER
TUNGSTEN
ZINC-LEAD
NON-METALS
ANDALUSITE & KYANITE
BARITE
BUILDING STONE
SANDSTONE
GRANITE
SLATE
CLAY
DIATOMITE
GEMS
GYPSUM
IODINE
LIMESTONE, CEMENT, MARBLE
MAGNESITE
MICA
▼ PUMICE
# SALINES
SOAPSTONE
SULPHUR
TALC
W WOLLASTONITE
SANTA CLARA
MERCED
SANTA CRUZ
MADERA
FRESNO
SAN BENITO
MONTEREY
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
NEVADA
ARIZONA
MEXICO
37°
36°
35°
34°
33°

ADMINISTRATION

ADMINISTRATIVE REPORT

By Walter W. Bradley, State Mineralogist

Personnel

Eldridge D. Drew, geological draftsman, has transferred to the Division of Architecture, Department of Public Works, Sacramento. He had been with the Division of Mines since January 1941.

New Publications

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, July and October 1942, being chapters 3 and 4 (combined) of State Mineralogist's Report XXXVIII. This issue contains: *Current Notes* of the Geologic Branch; *Hot Springs Deposits of the Coso Mountains; Contact Metamorphic Rocks of the Twin Lakes Region, Fresno County; Tungsten Deposits of the Confidence Mining District, Tuolumne County; Geology of the Welsh Tungsten Deposits, Madera County; Ghost Canyon Tungsten Claims, Madera County; Tabulation of Tungsten Deposits of California, to Accompany Economic Mineral Map. No. 4* (in pocket). Under Special Articles: *Biennal Report of the State Mineralogist.*

BULLETIN 118, Parts Three and Four (paper-covered preprint bound together). Part Three—*Descriptions of Individual Oil and Gas Fields;* Part Four—*Glossaries, Bibliography, and Index;* state map in pocket.

COMMERCIAL MINERAL NOTES, May, June, July, 1943. These 'Notes' contain the list of 'mineral deposits wanted' and 'mineral deposits for sale' issued in the form of a mimeographed sheet monthly. This sheet is mailed free to those on the mailing list for the *California Journal of Mines and Geoolgy.* It may be separately subscribed for at 25¢ per year.

SAN FRANCISCO FIELD DISTRICT

CARBON DIOXIDE GAS OCCURRENCES IN MENDOCINO AND NORTHERN SONOMA COUNTIES

By Henry G. Hubbard *

General interest in the commercial possibilities of natural carbon dioxide (CO_2) gas production in Mendocino and northern Sonoma counties has been aroused by pioneering work of the Caldri Ice Corporation, 1168 Battery Street, San Francisco. This concern has been producing dry ice for the San Francisco area market during the past four years. Its plant, superintended by Henry De Lotty, is located on the east bank of the Russian River at Largo, two miles north of Hopland in Mendocino County.

The Caldri ten-ton capacity plant is the only present producer in northern California of natural CO_2 gas, liquid, or dry ice. It followed six years after the initial California well production reported in 1933 by the State Division of Mines at the Niland (Imperial County) gas field southeast of the Salton Sea. Two companies in the southern California field are making nearly 60 tons of dry ice daily from some 40 gas wells averaging 650 feet in depth and flowing through a $\frac{1}{8}$-inch or $\frac{1}{4}$-inch bean to deliver gas at a pressure of 175 pounds per square inch for some wells.

As shown on the accompanying flow-sheet, pressure fluctuates between +8 and —10 inches on a mercury column for the six Caldri producing wells. These wells are about 350 feet deep in the river-valley alluvium and were drilled close to strong seeps of CO_2 gas bubbling up through the Russian River. Seep No. 9 on the accompanying map indicates the Caldri plant and wells. Other CO_2 gas seeps under lease by this corporation are shown as Nos. 6, 7, and 8.

The area covered in this article was visited by the writer on June 22-24, 1943, and the three properties upon which gas analyses are included (Nos. 9, 10, and 12 on the map) were personally observed. All of the ten others mapped were reported to be apparently of commercial quality, free from harmful ingredients, by Henry De Lotty, whose valuable contributions to this report are hereby acknowledged. The question of available pressures and volumes for the various occurrences will of course have to be answered by drilling shallow wells as was done at Largo.

The CO_2 gas seep reported in Cummiskey Creek on the Beattie Ranch, Mendocino County, where all mineral rights are under lease to the O. J. Scherer Company of Las Vegas, Nevada, was tested by De Lotty and the writer. The true gas sample so collected by displacement of water was analysed on July 1, 1943, by Smith Emery & Co., of San

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* Junior Mining Engineer, San Francisco Field District. Manuscript submitted for publication August 10, 1943.

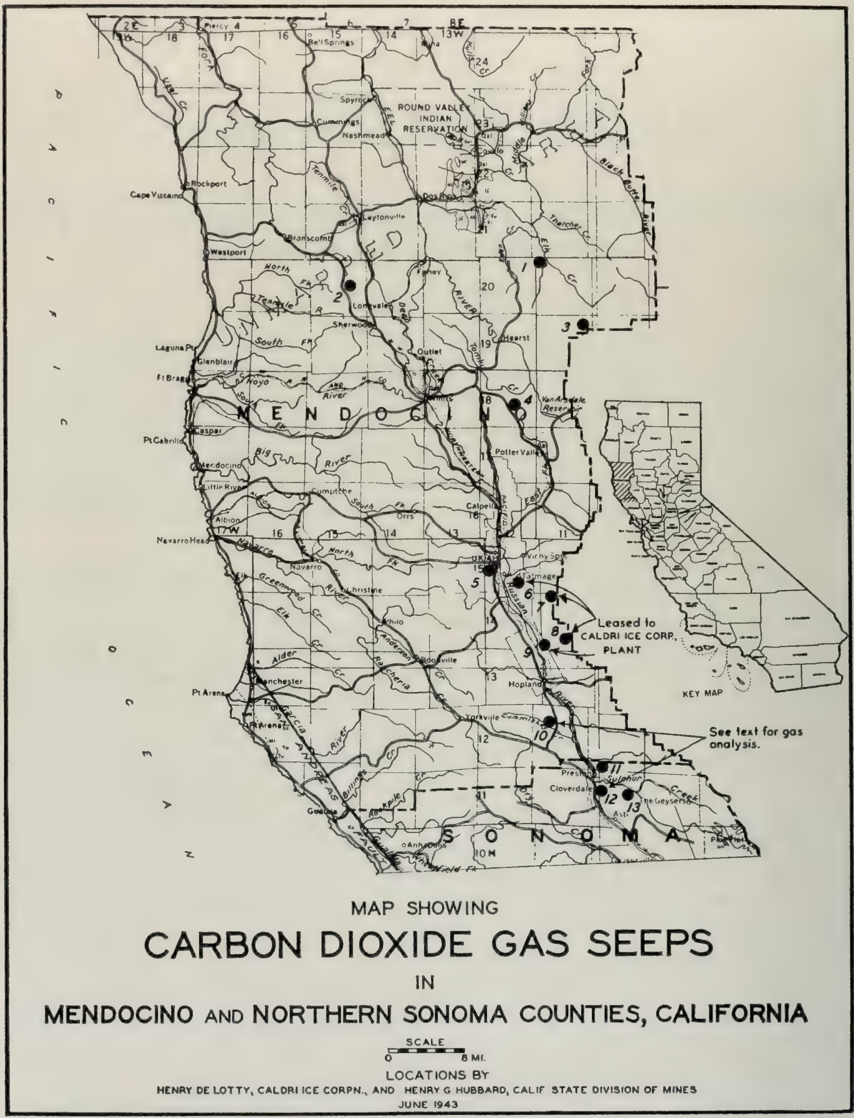
MAP SHOWING
CARBON DIOXIDE GAS SEEPS
IN
MENDOCINO AND NORTHERN SONOMA COUNTIES, CALIFORNIA
SCALE
0
8 MI.
LOCATIONS BY
HENRY DE LOTTY, CALDRI ICE CORPN., AND HENRY G HUBBARD, CALIF STATE DIVISION OF MINES
JUNE 1943
MENDOCINO
SONOMA
PACIFIC OCEAN
ROUND VALLEY INDIAN RESERVATION
Leased to CALDRI ICE CORP. PLANT
See text for gas analysis.
KEY MAP
Rockport
Cape Vizcaino
Westport
Laytonville
Branscomb
Longvale
Sherwood
Laguna Pt
Glenblair
Ft Bragg
Caspar
Pt Cabrillo
Mendocino
Little River
Albion
Navarro Head
Navarro
Comptche
Philo
Boonville
Manchester
Pt Arena
Gualala
Anchor Bay
Ukiah
Talmage
Vichy Spr
Potter Valley
Calpella
Hopland
Yorkville
Preston
Cloverdale
The Geysers
Asti
Hearst
Outlet
Willits
Spyrock
Cummings
Nashmead
Covelo
Dos Rios
Bell Springs
Piercy
Van Arsdale Reservoir
Orrs
Navarro River
Big River
Noyo River
Eel River
Russian River
Garcia River
Gualala River
Alder Cr
Greenwood Cr
Elk Cr
Rancheria Cr
Anderson Cr
Sulphur Creek
Dry Cr
Big Sulphur Cr
Black Butte River
Thatcher Cr
Middle Fk
Tenmile Cr
SAN ANDREAS FAULT
1
2
3
4
5
6
7
8
9
10
11
12
13

FIG. 1. Map showing carbon dioxide gas seeps in Mendocino and northern Sonoma counties, California.

Francisco, and reported on their laboratory form SE No. 171055 as follows:

Carbon dioxide (CO_2)	84.50%
Hydrogen sulphide (H_2S)	NIL
Methane (CH_4)	11.60
Hydrogen (H_2)	NIL
Nitrogen (N_2)	3.90
Total	100.00

NOTE.—No odor except that of carbon dioxide could be detected.[1]

---

[1] CO_2 gas has a faint characteristic odor. *H.G.H.*

The above gas seep is reached by one-quarter mile of level dirt road from the ranch house located on a good surfaced county road. It is a strong, steady seep and was given greater significance by the subsequent report (July, 1943) of another CO_2 showing about 1500 feet west of the one tested. This later discovery in wet mud of a small side-hill spring was made by Fred Spakman, foreman of the crew engaged in core-drilling a nearby quicksilver orebody which is being developed by the Scherer Company.

The CO_2 gas seep mapped on or near the eastern city boundary of Cloverdale, Sonoma County, was also visited but found to be trampled over by stock or otherwise rendered unavailable for proper sampling in its present condition. It was bordered by a growth of ''turpentine'' weeds [2] which were present at the two other seeps visited but not observed anywhere else. These small weeds with blue or sometimes yellow flowers have a strong, unpleasant odor somewhat resembling vinegar and have been used by De Lotty as an indication of CO_2 gas seeps in California, Texas, Utah, and elsewhere. The Cloverdale seep was carefully sampled by R. E. Thompson, Box 2, Cloverdale, when the CO_2 gas was flowing strongly from a 2-inch iron pipe fitted to an inverted steel drum set in the mud over the seep in 1930. Thompson contributed his copy of a Smith Emery & Company analysis of his sample dated February 20, 1930, which reports—

Carbon dioxide (CO_2)	87.2%
Oxygen (O_2)	0.3
Carbon monoxide (CO)	None
Hydrogen (H_2)	None
Hydrogen sulphide (H_2S)	None
Higher hydrocarbons	None
Methane (CH_4)	10.2
Nitrogen (N_2)	2.3
Total	100.0

The rapidly expanding uses of CO_2 gas, liquid, or dry ice are so numerous that it is very doubtful whether a truly complete list has been or can be made. However, a recent exhaustive article on the Niland CO_2 Gas Field by Stephen H. Rook and George C. Williams appearing in *Summary of Operations, California Oil Fields* [3] gives an extensive and representative list of CO_2 gas uses. The following list is therefore submitted from the above article by courtesy of the State Division of Oil and Gas:

USES

> Carbon dioxide is marketed either as a solid (dry ice) or as a liquid (liquid carbonic). Even if the ultimate use of the carbon dioxide requires it to be a gas, it is purchased from the manufacturer as a solid or liquid and sublimed or reduced to a gas at the place of use. In addition to the normal uses, the war effort is consuming large amounts of the gas.
>
> Some of the normal uses of carbon dioxide which have been adapted to military and naval requirements, information concerning which has been made public, are as follows:
>
> Refrigerating for cooling rooms to stratosphere conditions. Cold shrinking of machine parts and cylinder liners, etc. Heat and cold treating of aluminum and special steel alloys. Cooling of radio tubes, etc.
>
> Fire prevention and extinction, as in planes, tanks, ships, etc. Inflation of life preservers and rubber boats.

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[2] Trichostema laxum.

[3] Vol. 28, no. 2, Annual Report of the State Oil and Gas Supervisor, July-December, 1942.

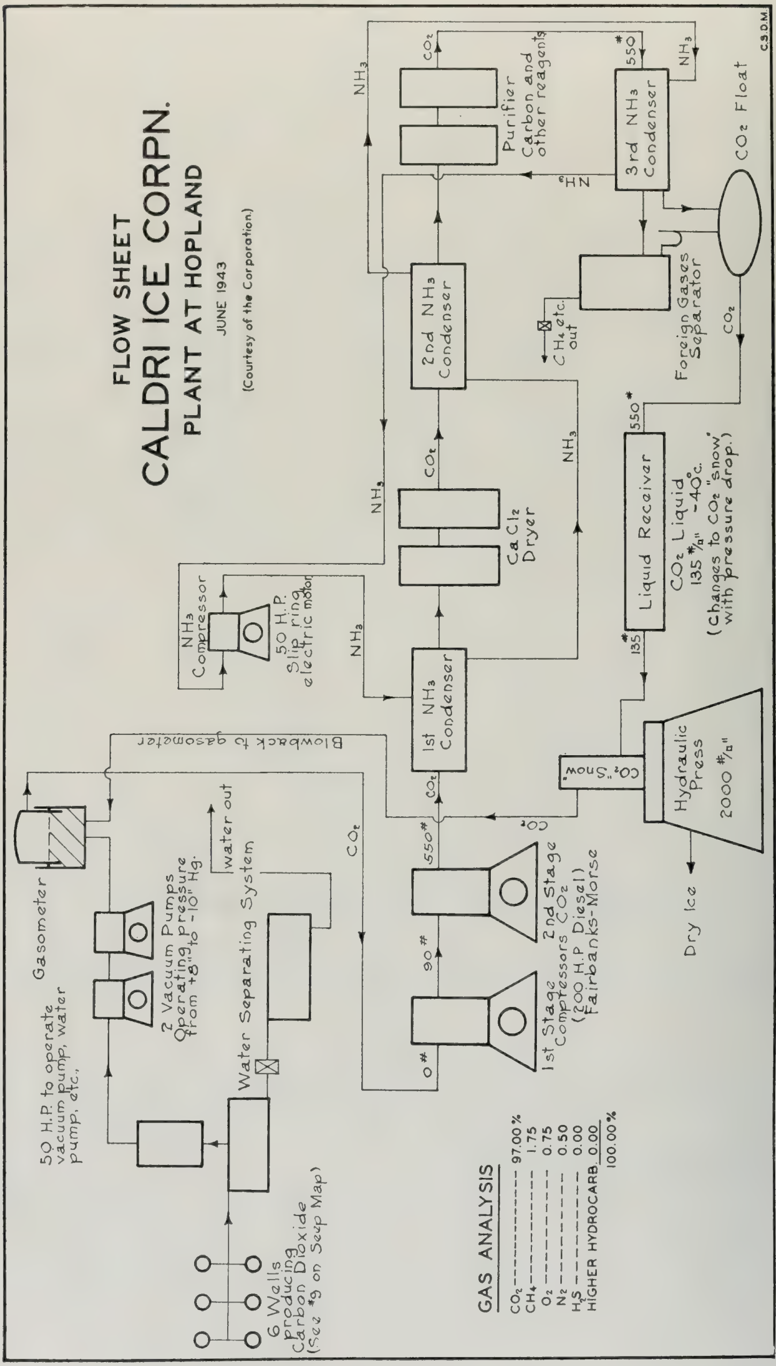
FLOW SHEET
CALDRI ICE CORPN.
PLANT AT HOPLAND
JUNE 1943
(Courtesy of the Corporation)
6 Wells producing Carbon Dioxide (See #9 on Seep Map)
50 H.P. to operate vacuum pump, water pump, etc.,
Water Separating System
water out
2 Vacuum Pumps Operating pressure from +8" to -10" Hg.
Gasometer
Blowback to gasometer
CO₂
0#
90#
550#
1st Stage Compressors CO₂ (200 H.P. Diesel) Fairbanks-Morse
2nd Stage
NH₃ Compressor
50 H.P. Slip ring electric motor
NH₃
1st NH₃ Condenser
CaCl₂ Dryer
2nd NH₃ Condenser
Purifier Carbon and other reagents
3rd NH₃ Condenser
550#
CO₂ Float
Foreign Gases Separator
CH₄ etc. out
550#
Liquid Receiver
135#
CO₂ Liquid 135#/□" -40°C.
(Changes to CO₂ "snow" with pressure drop.)
CO₂ "Snow"
Hydraulic Press 2000#/□"
Dry Ice
GAS ANALYSIS
CO₂ ---------- 97.00%
CH₄ ---------- 1.75
O₂ ---------- 0.75
N₂ ---------- 0.50
H₂S ---------- 0.00
HIGHER HYDROCARB. 0.00
100.00%
C.S.D.M.

FIG. 2. Flow sheet, Caldri Ice Corporation plant at Hopland.

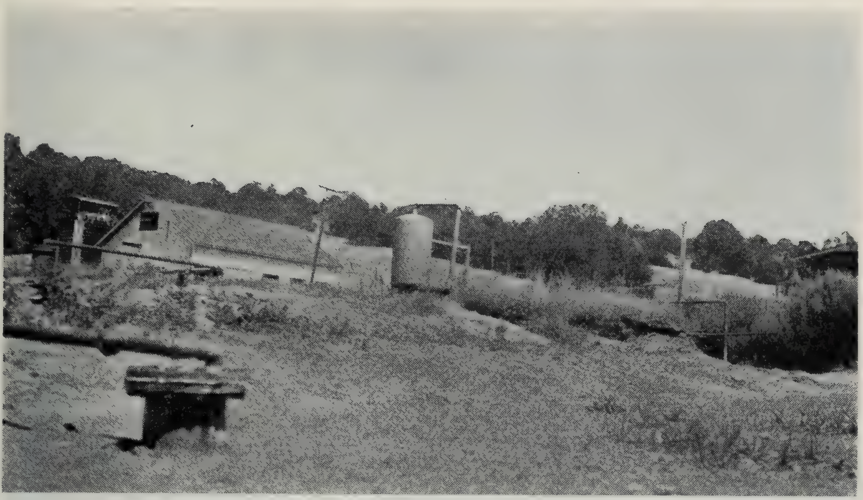

FIG. 3. Caldri Ice Corporation wells and plant at Largo. Showing 12-inch casinghead in left foreground; water separator in center; vacuum pump house at extreme right; plant in left center. June 1943.

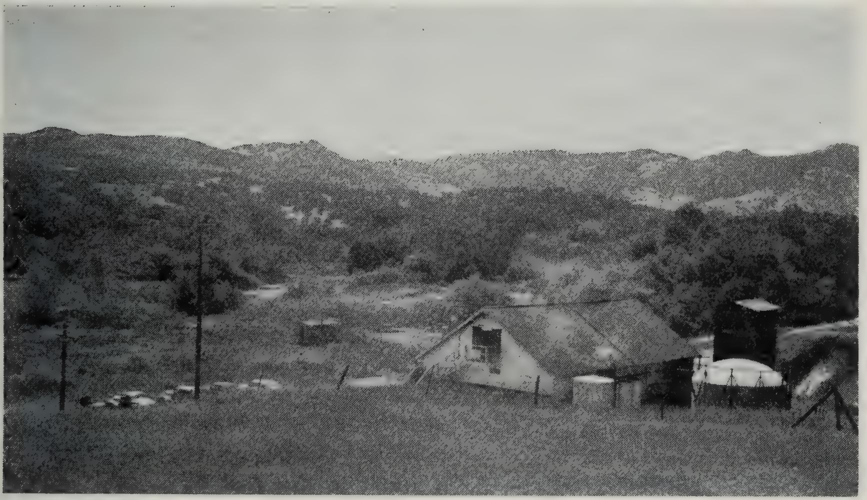

FIG. 4. Caldri plant and gasometer (at right); vacuum pump house in center; Russian River in middle distance. Looking west from Old River Road. June 1943.

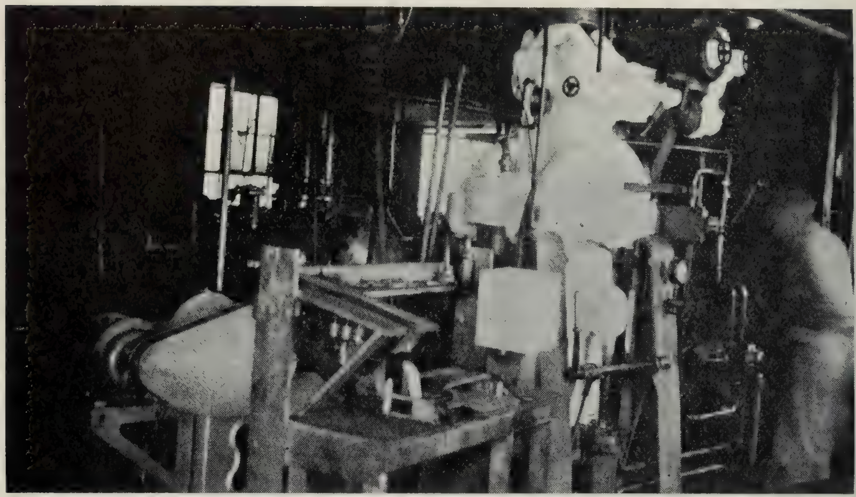

FIG. 5. Hydraulic ice press, operated by Henry De Lotty in the Caldri plant. Newly pressed ice cake in center weighs about 66 pounds and measures 10 by 10 by 11¼ inches. June 1943.

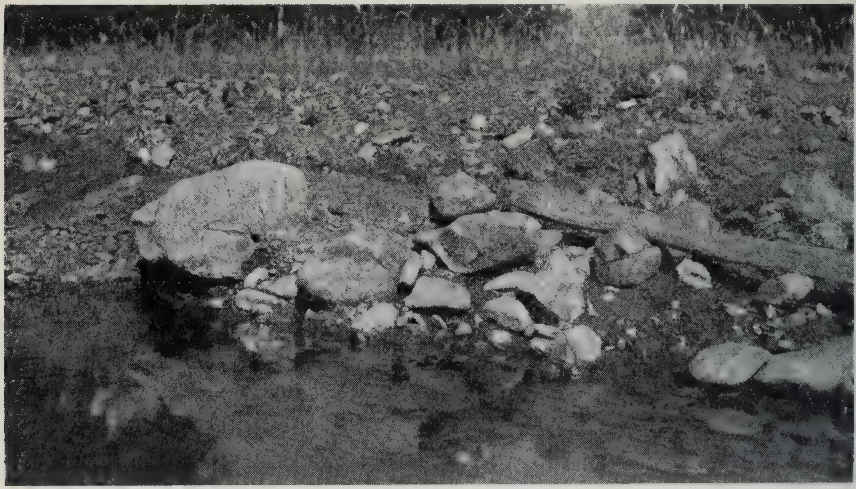

FIG. 6. Cummiskey Creek CO_2 seep on Beattie Ranch. Gas bubbles cause the ripples here shown in stagnant water on a windless day. June 1943.

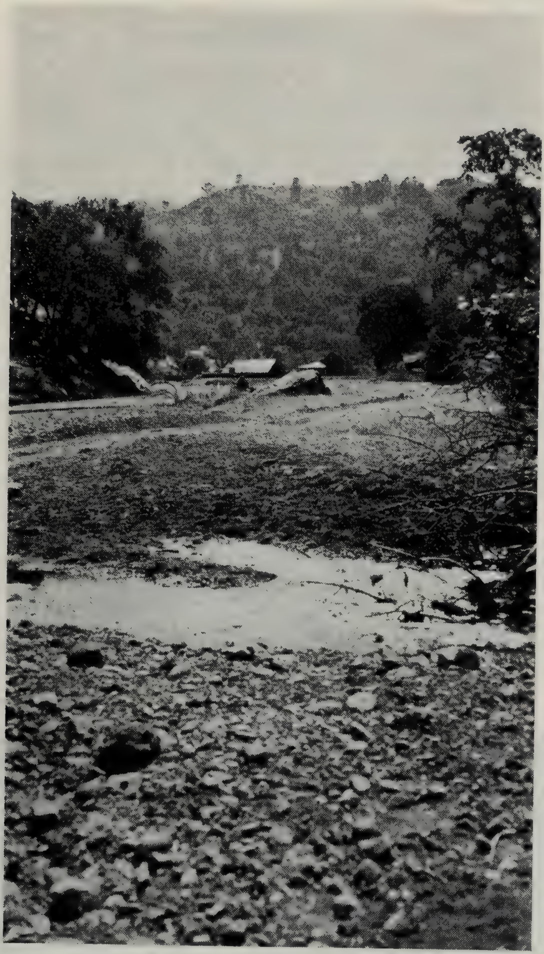

FIG. 7. Cummiskey Creek seep in foreground showing the Beattie ranch house on a good country road distant a quarter of a mile (view eastward downstream). June 1943.

De-waxing of specially treated oils for use in high altitude or very low temperatures.

Stand-by power for plane landing gear when hydraulic power fails.

Treatment of cellular and other rubber products.

Normal uses for carbon dioxide are even more numerous than those of war-time; and although there is a certain overlapping, the principal common uses not previously mentioned are as follows:

Solid Carbon Dioxide

Refrigeration. Includes package refrigeration, truck, railroad, ice cream dispensers, etc. This refrigeration is principally used in the transportation and storage of meats, fish, fruits, vegetables, and ice cream.

Heat and cold treatment. Includes, as a retarder for the handling and use of air hardening metals, shrink fitting as in cylinder liners, hardening as in certain special steel alloys which can be machined first, then tempered by chilling.

Laboratory uses. As in dehydration of biological serums, thin sections, etc.

Liquid Carbon Dioxide

Refrigeration. As in compression refrigerating systems. This type of system is exceptionally dependable, and there is no danger to life in case of leakages—most generally used in ships, theaters, etc.

Blasting. As in "Cardox Blasting." Used in coal mines. The cost is greater than black powder but is safer and does not break up the coal as much as powder blasting. Also saves man hours since blasting may be carried on while the miners are in the vicinity.

Power. May be used as bottled power for any purpose in which compressed air is generally used but may not be as cheap.

Gaseous Carbon Dioxide

Carbonating beverages. This is probably the second largest use of carbon dioxide in point of volume. It is used in manufacture of carbonated water, soda pop, and other sparkling beverages.

Fire extinguishing. Will extinguish quickly all fires except those which may occur in chemically treated material to which sufficient oxygen to support combustion has been added.

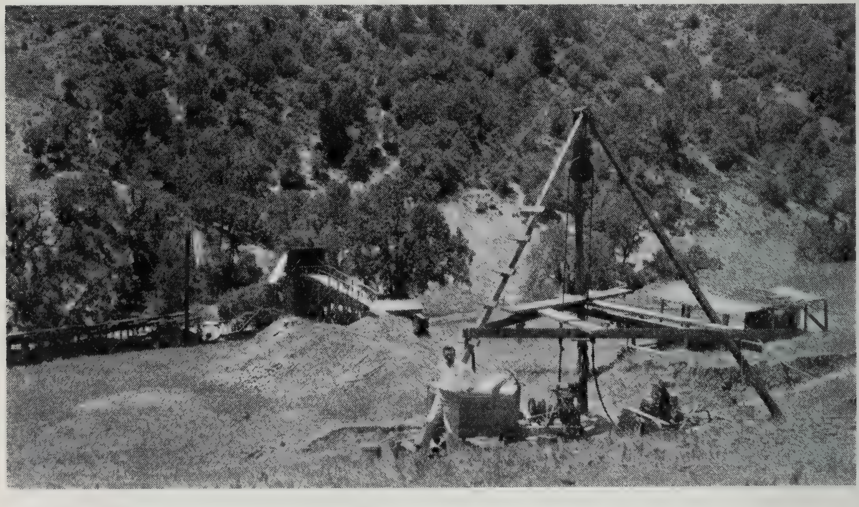

FIG. 8. Diamond drill of O. J. Scherer Company core-drilling for cinnabar near Cummiskey Creek on Beattie Ranch. Foreman Fred Spakman at rig; ore bin and dump in left center; quicksilver retort under shed at left. June 1943.

Preservation. Conservation of fruits, vegetables, meat, fish, eggs, flowers, etc., may all be prolonged by the proper treatment of the product with carbon dioxide gas used under set conditions. This treatment will also assist in the prevention of spoilage in canned goods which are subject to spoilage by oxidation, such as cocoa products, coffee, powdered milk, sweetened shredded cocoanut, etc.

Chemically. Used in the chemical trades most commonly for the manufacture of carbonates. These processes often do not require carbon dioxide in the pure state. In the solid form, carbon dioxide is the only cheap, non-corrosive, acid anhydrid which can be shipped without special containers and handled easily with entire safety.

Power. Carbon dioxide, if used as a source of power to project liquid sprays onto trees and plants, will stimulate respiration of insects, making the poisonous gases more effective. It will increase the rate of growth of the plants. It will reduce the fire and explosion hazard when mixed with inflammable fumigants and is a type of indirect fertilizer. Carbon dioxide alone would probably be of little value as a fumigant except where it can be used in a gas-tight chamber.

Carbon dioxide in either the gaseous or solid state has been used with beneficial results in numerous human ills. Particularly is this true when the solid carbon dioxide is used as an escharotic in the treatment of certain dermatologic diseases, and the gas as a stimulant to respiration and in the suppression of hiccoughing.

The presence of variable percentages of methane (CH_4 or ''marsh gas'') should be noted as a possible by-product valuable for fuel. Caldri Ice Corporation is not now exploiting the 1.75% of methane present in its operating wells but may do so at some future date since this material is separated and easily recoverable as shown in the flow-sheet. The Cloverdale CO_2 gas seep might very well make a commercial product of methane gas as the combined content (2.6%) of nitrogen and oxygen present with the 10.2% of CH_4 that would separate upon liquefaction of the CO_2 content would not seriously dilute the methane as a fuel gas. Likewise methane amounting to 11.6% in the Cummiskey Creek occurrence of CO_2 gas could easily be recovered and consumed as fuel in the quicksilver-processing furnace distant only 1500 feet on the same property.

Mendocino and northern Sonoma counties apparently offer numerous opportunities for an increased production of the well-known war-essential mineral, carbon dioxide, either as a gas in pipe lines or pressure containers, or as a liquid or solid (dry ice) in commercial packages.

Bibl.: XII, pp. 407-408; XXXVIII, pp. 144-145; pp. 198-201; XXXIX, p. 36; B. 122, p. 84.

SACRAMENTO FIELD DISTRICT

CURRENT NOTES ON ACTIVITY IN THE STRATEGIC MINERALS, SACRAMENTO FIELD DISTRICT

By Charles V. Averill *

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AMADOR COUNTY

Manganese

Garibaldi Brothers Lease. Property amounting to 40 acres in sec. 35, T. 7 N., R. 12 E., M. D., is leased from Ben Perini of Pine Grove by Garibaldi Brothers of Volcano. The two brothers have been working the property since late in 1942. Black oxides of manganese crop out on the crest of a ridge, and the miners first did 400 feet of adit-work in various directions reaching a maximum depth of 60 feet below the surface. This work was not successful in developing a commercial body of ore. Work in June 1943 was in a 74-foot shaft. A level had been established at the 50-foot point, and manganese ore was found 6 feet east of the shaft. A drift was run on it for a distance of 25 feet to the south. The strike is south, and the dip is not well exposed, but probably it is vertical. Manganese ore is seen for the width of the drift, about 6 feet, and the full width of the orebody is not exposed. Twenty tons of manganese ore that appeared to be of good quality was piled at the collar of the shaft. Work was proceeding in easterly and westerly directions on the 65-foot level of the shaft in an effort to locate the same shoot of ore on that level. As an outcrop of manganese ore is seen on the surface just to the east of the shaft, it seemed probable that considerable additional ore could be mined from the 50-foot level to the surface. The black oxides of manganese occur in a sedimentary series of slates and cherts, and this series is intruded by a decomposed igneous dike, probably rhyolitic. Equipment includes hoist and air-compressor driven by gasoline engines, and air-drills.

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* District Mining Engineer, Sacramento Field District, California State Division of Mines. Manuscript submitted for publication August 16, 1943.

Payton Property. Lee Payton, Pine Grove, owns a 40-acre patented tract in sec. 35, T. 7 N., R. 12 E., M. D., one mile from the paved road running from Pine Grove to Volcano. The property was visited before present operators started to work it. Lenses of manganese ore consisting of black oxides strike northwest and dip 76° NE. A width of 8 feet was seen in a cut 15 feet deep. At a point 50 feet to the south were two shafts and a connecting adit on parallel lenses. A depth of 15 feet below the surface had been reached, and a little stoping had been done. These workings were partly caved, but the length of the lenses in sight seemed to be about 25 feet. Hand-sorting is needed to keep silica down to the proper amount in this ore. Country rock is a sedimentary series of slates and cherts, probably with some volcanic material interbedded. Much of the chert has been recrystallized so that it has the appearance of quartzite. During the war of 1914-18, 30 tons of ore was shipped from this deposit.

The property was being worked in June, 1943, by Crabtree, Sullivan, and Stewart of Jackson, who had some ore about ready to ship to stockpiles of Metals Reserve Company.

BUTTE COUNTY

Copper and Zinc

Big Bend Mine. This mine is being operated by Hoefling Brothers, 1820 D Street, Sacramento. Wm. E. Messner, Route 1, Oroville, is superintendent. The property consists of five unpatented mining claims in sec. 8, T. 21 N., R. 5 E., M. D.

A vein of heavy sulphide ore strikes N. 30° W. and has an average dip of 62° NE. Average width is 42 inches for a length of 100 feet. The shaft was 180 feet deep and was being sunk deeper in June, 1943. A working-level had been established at 100 foot depth. On this level the vein is 2 feet to 6 feet wide for a 100-foot length bounded by a fault on the southeast. One small segment had been developed to the southeast of this fault, and diamond drilling was under way to locate another segment. Traces of the same structure have been found in six places in a length of 1000 feet on the surface. Country rock is amphibolite schist. Mine equipment includes a portable compressor driven by diesel engine, capacity 315 cubic feet of air per minute. The hoist on the shaft is operated by compressed air.

Ore is hauled 5 miles to the Surcease mill, which has a capacity of 100 tons, but was treating 25 tons per day in June. It contains a crusher, 6-foot by 5-foot ball mill, $4\frac{1}{2}$-foot Dorr-type classifier. Ore is ground so that 90 percent passes a 150-mesh screen. It then goes to four Fagergren 44-inch flotation cells. Four 30-inch Kraut cells are used as cleaners. Tailing from these cleaners is being saved for further treatment for copper. Cleaner concentrate runs 50 percent zinc, 5 to 6 percent copper, and 7 percent iron. It is shipped to Bunker Hill & Sullivan in Idaho. Concentrate is dewatered with a 6 foot by 8 foot Eimco drum filter and the tailing from the cleaner cells is dewatered on a 2 foot by 4 foot Dorco filter. Nine men were employed in the mill and on the surface in June 1943 and nine in the mine.

CALAVERAS COUNTY

Copper and Copper-Zinc

Collier Mine. This mine is in sec. 24, T. 1 N., R. 11 E., M. D. E. A. Vogt and others, 407 Montgomery Street, San Francisco, are leasing 19 acres. Manuel Bettencourt, Copperopolis, is foreman at the mine. Development work consists of a 130-foot shaft following vein which is 5 feet to 6 feet wide. The vein strikes northwestward and dips 50° NE. To the end of June 1943, five carloads of ore had been shipped to Combined Metals Reduction Co., Bauer, Utah. It runs 14 percent zinc, 1½ percent copper, and a little lead, gold, and silver. A few hundred feet away from the vein, on the surface, in the footwall, is a green dacite or rhyolite. A few hundred feet in the hanging wall is an andesitic greenstone. Country rock of the vein is so sheared and altered that it is difficult to tell whether or not the vein is on the contact of these two formations. The ore contains considerable gangue in the form of country rock, also probably some barite, and the grade could probably be raised considerably by milling. Ore minerals are chiefly pyrite, chalcopyrite, and sphalerite. Equipment consists of a portable gasoline-driven compressor, gasoline hoist, headframe, and ore-bin.

Keystone Mine. This mine was operated during 1942 and the early part of 1943 by Keystone Copper Co., a limited partnership. Charles W. Stewart and Claude E. Nuss, 410 Thorne Street, Fresno, California, are general partners, H. E. Bush, Superintendent, and F. W. H. Beauchamp are limited partners. It is in secs. 33, 34, T. 2 N., R. 12 E., M. D., at Copperopolis.

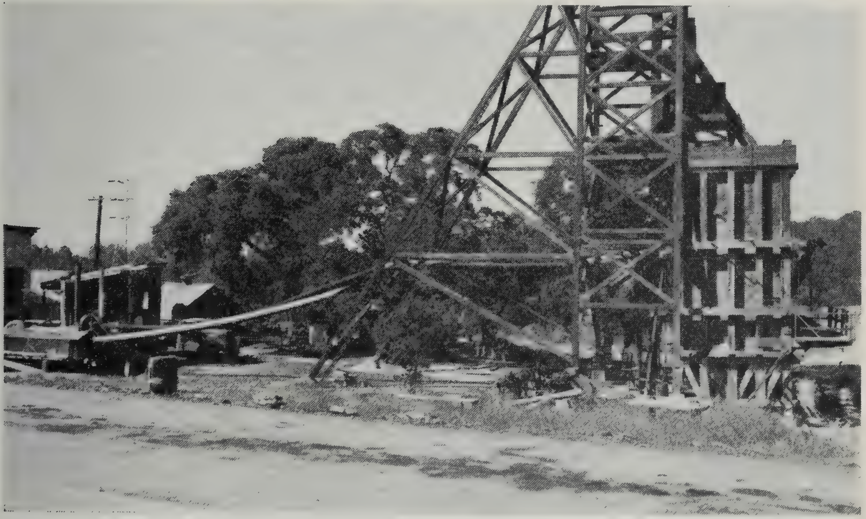

FIG. 1. Surface plant at Keystone mine, Calaveras County.

In a period from June 1929 to July 1930, Engels Copper Mining Co. put down a vertical shaft for 675 feet to develop the northwest extension of the same vein formerly mined. The vein strikes NW and dips NE. The shaft passed through the vein at a depth of 375 feet. On the 525-foot level crosscutting of 50 feet was required and on the 675-foot level crosscutting of 116 feet. On the 525-foot level 400 feet of drifting was run each way from the crosscut. On the 675-foot level drifting was done 15 feet each way from the crosscut.

On June 23, 1943, the output from the present operation had amounted to 102 carloads of concentrates of about 50 tons each running 20 to 23 percent copper. This ore comes entirely from the lowest level at a depth of 675 feet. The orebody is 350 feet long and 15 to 20 feet wide. There is also a shorter orebody in the footwall of this main orebody. This ore is apparently on the same shear-zone as the ore in the old Union mine, with which it is in line.

The property is now being operated by Lava Cap Gold Mining Corporation, Otto E. Schiffner, General Manager, John W. Chandler, Superintendent. The output is 200 tons of ore per day, which is milled at the Mountain King mill by selective flotation. Present operators are planning to sink the shaft an additional 600 feet immediately. They plan to increase the tonnage to 450 tons a day and to revise the milling in the present mill. Experiments are to be made with making a bulk concentrate at 30-mesh, then regrinding this first concentrate for a second treatment by flotation to separate the chalcopyrite from the pyrite. Installation was being made in June 1943, of an air compressor of 1700 cubic foot capacity driven by a synchronous electric motor. An 800 cubic foot compressor was already in use. The geology of the mine has been mapped recently by George R. Heyl and J. B. Hadley, geologists of the U. S. Geological Survey.

Napoleon Mine. This mine, located in sec. 23, T. 1 N., R. 11 E., is owned by Edward H. Nutter. The Mountain Copper Company, Ltd., 351 California Street, San Francisco, started to re-open the mine in 1942, but the property was idle in June 1943. J. M. Basham was in charge of what work was done.

Pacific Mining Company. This company maintains offices at 1022 Crocker Building, San Francisco, and at Jamestown, Tuolumne County. P. R. Bradley, Jr., is president and general manager. W. F. Lyon is superintendent at the operation mentioned below.

The company is building a flotation plant in sec. 2, T. 1 N., R. 12 E., M. D., to treat an old accumulation of tailing from the Copperopolis copper mines amounting to about 750,000 tons. The plant will consist of a small ball mill and flotation cells, and is expected to treat about 1200 tons per day. Two earth dams, each about 20 feet high and 200 feet long, have been built down-stream from the present tailing pond. The first is for storing the re-worked tailing, and the second is for collecting water to pump back for re-use. A store-room and office building have been built, and pipe is being installed for a water supply from Black Creek. Concrete foundations for the new mill were being poured in June 1943.

Quail Hill Mine. This mine is owned by G. Ivan Smith, 4333 East Florence Ave., Bell, California. Roy Kirk, Copperopolis, is superin-

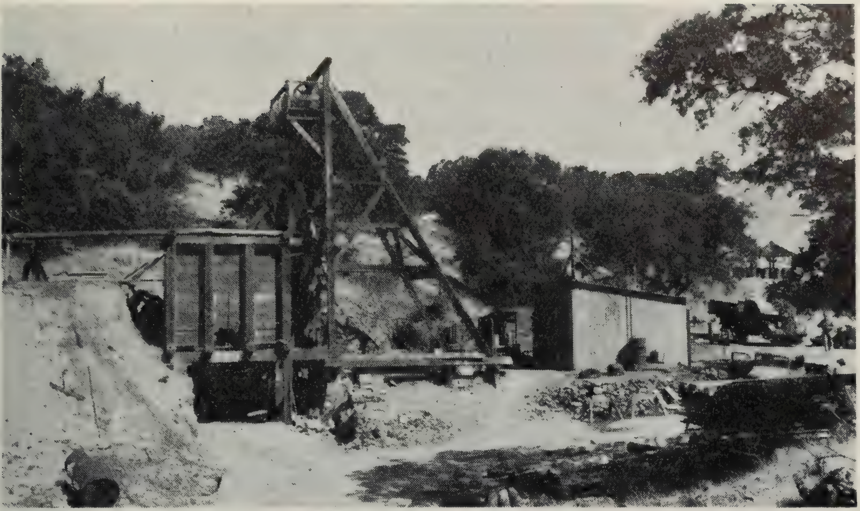

FIG. 2. Quail Hill mine, Calaveras County.

tendent. It is located in sec. 3, 10, T. 1 N., R. 11 E., M. D., and includes one patented claim and a mill site.

A shear-zone 40 to 50 feet wide strikes N. 40° W. and dips 60° NE. Very irregular pockets of sulphide ore from 1 foot wide to 25 feet wide are found in this shear-zone. The longest so far found was 45 feet long. The mine was being operated by a crew of eight men and was equipped with portable type gasoline compressor and gasoline hoist in June 1943.

Development work consists of a 315-foot vertical shaft with levels at 70 feet, 170 feet, 235 feet, and 300 feet. The 170 is an old caved level of which 180 feet has been cleaned out recently. The 235 is a new level consisting of 140 feet of drifting to the northwest. On the 300 is 100 feet of drifting to the southeast and 135 feet to the northwest. Most of the ore has been found northwest of the shaft. Shipments so far have amounted to 1100 tons. Ore is shipped to International Smelting Company, Utah. It runs 22 percent zinc, 5½ percent copper, 0.4 ounces gold, 6 ounces silver per ton.

The shear-zone has a greenstone hanging wall. The rock of the footwall is decomposed, probably by acid leached from the vein. It appears to have been originally a schist. The ore consists of pyrite, chalcopyrite, and sphalerite. Underground geology was being mapped by George R. Heyl and J. B. Hadley of the U. S. Geological Survey in June 1943.

Quartz Crystal[1]

Calaveras Crystal Mine. F. R. Zinck, John Bevenda, and Nick Bulum, 322 Elks Building, Stockton, are leasing from R. P. M. Davis about 200 acres of land in sec. 24, T. 5 N., R. 11 E. and sec. 19, T. 5 N.,

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[1] The Department of the Interior, Geological Survey, has recently issued Information Service P. N. 25853 (September 4, 1943), *The Rough Diamond Crystal Mine and the Calaveras Crystal Mine, Calaveras County, California;* and the following Strategic Minerals Investigation Preliminary Maps: *Rough Diamond Crystal Mine, Calaveras Crystal Mine, Calaveras County, California,* survey by Thomas P. Thayer and Cordell Durrell, June 1943; and *Cross Sections, Rough Diamond Crystal Mine, Calaveras Crystal Mine, Calaveras County, California,* survey by Thomas P. Thayer and Cordell Durrell, June 1943.

R. 12 E., M. D. The Green Mountain Placer mine, Green Mountain Extension Placer mine, and the Boucher and Brackett Placer mine are included.

Quartz crystals are found in an ancient river channel, the "Tunnel Ridge Channel," shown on map of Ancient Channel System of Calaveras County issued by this division. In June 1943, the 675-foot point had been reached in an adit level. Work was started in an old adit at the 475-foot point, and is new beyond that point. The adit runs S. 35° E. for 475 feet, then S. 20° W. for 60 feet, and the remainder in a southeasterly direction. New drifts were being started to the northeast and to the southwest to follow the far rim of the channel. Both rims of the channel are exposed. The first rim is exposed about 300 feet from the portal of the adit. The channel is about 250 feet wide and flowed to the southwest.

A shipment recently has been made of 90 pounds of quartz crystals believed to be suitable for controlling radio transmitters. This amount was trimmed from a total of 300 pounds of crystals taken from the mine. The best crystal weighed 103 pounds. Another weighed 73 pounds, another 32 pounds, and several weighed 15 pounds each. The lessees have one 63-pound crystal in Los Angeles also. Equipment includes a portable air compressor driven by a gasoline engine.

Rough Diamond Mining Company. This company, the address of which is Mokelumne Hill, is a partnership of E. C. Setzer, Edwards L. Brinkman, and K. P. McDaniel, who are leasing property from John J. McSorley and Thomas E. McSorley in sec. 24, T. 5 N., R. 11 E., M. D. S. Menchini, Box 4, San Andreas, is superintendent in charge of the crew of three men.

Quartz crystals are found in the same ancient channel as that being developed by Calaveras Crystal mine adjoining (see above).

Present workings start just west of the highway from San Andreas to Mokelumne Hill and run S. 80° E. for 340 feet, then northeast 120 feet, then a 12-foot raise, then S. 80° E. 290 feet, then a 12-foot raise, then N. 30° E. parallel to the property line for 255 feet, then a 19-foot raise, which connects with an old working running north in the gravel-channel. The work starts in soft granodiorite bedrock, and the first raise entered the gravel-channel. Near the point where the second raise was started, quartz crystals were found and continued to be found for a distance of 70 feet in the drift bearing N. 30° E. The crystals seem to bear more to the northeast than the drift, and more development work to the east is planned. The drift running N. 30° E. is in a high ridge of bedrock-slate beyond the 150-foot point. Menchini states that crystals are found in three different strata for a total height of 16 feet above bedrock. The three strata of gravel are separated by two strata of sand. In May 1943 he said that 1600 pounds of good quartz crystals had already been shipped, of which 40 percent to 50 percent is usable material. The crystals are found in a 30- to 40-foot width of the gravel-channel.

COLUSA COUNTY

Quicksilver

Manzanita Mine. This mine is being operated by General Mercury Company, which may be addressed at either Natomas or Wilbur Springs. The property is in sec. 29, T. 14 N., R. 5 W., one mile west of Wilbur

Springs. A. E. Hall is manager, John Fulk is superintendent, and L. H. Davie is engineer.

A pilot plant has been built on the Wide Awake property about half a mile south of the Manzanita. It consists of an ore bin of 600 cubic yard capacity to receive ore from trucks. A 36-inch belt feeds the ore to a 52-inch by 30-foot trommel, of which a 15-foot section is punched with $\frac{3}{8}$-inch holes. Coarse material is rejected by this trommel and is stacked by a 36-inch belt 50 feet in length. Fines are fed to fourteen 42-inch jigs, of which 12 are roughers and 2 are cleaners. Four of the jigs are Bendelari, the rest are Pan-American. The hutch product of the cleaner jigs is fed to a 12-foot Wilfley table, from which a concentrate is obtained that runs $12\frac{1}{2}$ percent mercury. Power is furnished by two 13000 Caterpillar Diesel engines, which generate current at 440 volts.

A recent test has been made of soft disseminated ore found on the top of the hill above the old workings of the Manzanita mine. Roads were run around the hill, and test-pits were dug to produce 8000 cubic yards of ore. All of the material excavated from both the road-cuts and the test-pits was put through the pilot plant. The ore is decomposed, and tests have shown that 27.2 cubic feet are required to make a ton. The actual recovery from this operation is stated by the operators to have been 88 cents worth of quicksilver for each cubic yard handled. Plans call for continuing this operation with a $1\frac{1}{2}$-cubic yard dragline excavator. Production from December 1942 to May 1943 amounted to 100 flasks of quicksilver.

The concentrate from the Wilfley table is treated in a 15-foot rotary furnace with an outside diameter of 30 inches and an inside diameter of 20 inches. Heat is supplied by a butane burner made by Ransome Company, Emeryville. Liquid butane is fed directly to the burner, which is equipped with coils to quickly vaporize the butane. The capacity is four tons of ore or concentrate per 24 hours. Ordinary sheet steel is used for the condensing system with the exception of a final condenser consisting of a redwood tank, 4 feet square by 12 feet high.

A little ore has been produced from the Wide Awake at a contact between serpentine and a sedimentary series consisting of sandstone and shale. This serpentine contains inclusions of volcanic glass.

EL DORADO COUNTY

Chromium

Taylor Chrome Mine. J. J. Taylor, 1225 Russ Building, San Francisco, is leasing 200 acres of the Darrington ranch in sec. 34(?), T. 11 N., R. 8 E. Bulletin 76 of this division mentions a Buzzard mill on Levy-Darrington ranch, and this is probably a reference to the same deposit, as a mill was operated here during the war of 1914-18. Old open cuts indicate that roughly 1000 tons of disseminated ore was mined at that time.

The orebody at the open cuts is a lens about 300 feet long and 30 feet wide. S. A. Long of Auburn, superintendent, states that it runs 12 percent Cr_2O_3. Diamond drilling has proved that the ore extends from the bottom of the open cuts nearly to the level of a new adit, 70 feet lower in elevation. In July, 1943, this was 150 feet long, and plans called for driving a raise from the adit to the open cut.

At a distance of 500 feet to the west is an approximately parallel lens of disseminated ore 200 feet long and 6 feet wide. It strikes north, and the average dip is 45° E. The grade is stated to be about 25 percent Cr_2O_3. A 70-foot incline-shaft has been sunk on this lens, and drifts of a total of 40 feet have been driven at the bottom.

The property of the Auburn Chemical Lime Company has been purchased; also the mill from the New York mine, Greenville, Plumas County. The mill is to be erected on the former property of Auburn Chemical Lime Company and used to concentrate the chrome ore. Taylor holds a lease on the James Dobbas property adjoining the former property of Auburn Chemical Lime Company. Long states that on this property a lens of disseminated chrome ore is exposed for a length of 300 to 400 feet and a width of 30 feet. The Dobbas property was not being worked in July, 1943.

Tungsten

Bear Creek Tungsten Mine. This property includes three unpatented mining claims, Laurel, Laurel No. 1, and Laurel No. 2, in sec. 4, T. 11 N., R. 11 E., M. D., and a 5-acre patented camp-site in sec. 33 adjoining to the north. The owners are Mead Walker, Myneer Walker, and Forrest Riley, for whom H. G. Walker, Box 845, Placerville, is agent. The mining claims cover the same ground as the Comeback Consolidated group held by B. F. Magee and Lee Wolf about 10 years ago.

Scheelite is found in a fracture in chloritic schist and in a calcite vein in the schist. The old level of Magee and Wolf is at an elevation of 1900 feet. It started on a fracture in the schist carrying scheelite, and at the 100-foot point the adit intersected a calcite vein carrying scheelite. A turn was made in the adit to follow the vein, which strikes N. 7° E. and dips 50° W. The total length of this level is 187 feet. Scheelite is found in the calcite and to a smaller extent in the schist of the hanging wall, so that a stoping-width of 2½ to 3 feet is available. Considerable scheelite was to be seen in the top and ends of a small stope in July, 1943. This stope extends both above and below the level for a distance of 20 feet along the dip in each direction and for a length of 35 feet. A little work has been done in an upper adit and surface workings 50 feet higher in elevation than these main workings; also in an adit level 50 feet lower. This lowest adit is 100 feet long and is in schist for its entire length. It must be driven ahead to reach a point under the stope.

A little production has been made recently by running fine dump ore through a small jig. The product runs 67 percent to 75 percent tungstic oxide. H. G. Walker states that the dump yields 8 pounds of concentrate for each ton run through the jig. The camp in sec. 33 is 600 feet higher in elevation than the mine, and 1¼ miles of road to connect the two has been built recently. The deposit was discovered originally by Magee and Wolf while they were ground-sluicing for gold. They are said to have recovered \$3000 to \$4000 worth of scheelite from their sluice-boxes.

PLACER COUNTY

Chromium

Buzzard Mine. This mine is east of Iowa Hill in sec. 30, T. 15 N., R. 11 E., M. D. It was worked early in 1943 by H. R. Marall and B. S. Marall of Iowa Hill, who produced 10 tons of chrome ore running 46.87 percent Cr_2O_3 and 12.3 percent iron.

Vulcan Consolidated Chrome. This concern, of which John Kuenzli, Reno, Nevada, is manager started shipments of chrome ore from sec. 19, T. 15 N., R. 11 E., M. D., in July, 1943.

SIERRA COUNTY

Chromium

Oxford Quartz Mining Company. Property of this company in secs. 22, 23, 26, 27, T. 20 N., R. 10 E., M. D., one mile north of Downieville, was being worked for chrome ore in June 1943 by C. L. Best, Caterpillar Tractor Company, San Leandro, with L. L. Huelsdonk, Downieville, in charge.

The mill has been remodeled to treat chrome ore, and a new road has been built to reach deposits of disseminated chrome ore on the mountain above. The mill is at an elevation of 3500 feet, and the mine is 2500 feet higher; the length of haul is 2½ miles. The deposit being worked in June 1943 consisted of disseminated chrome ore with an average width of 7 feet for a length of 100 feet. The lens is known to extend some 30 feet additional along the strike. The strike is east, and the dip is very steep to the north. Mining and stripping are done with a ⅜-cubic yard Insley power shovel, and ore is hauled to the mill with a rubber-tired diesel-powered outfit known as a DW10 Caterpillar wagon. It has a capacity of 12 cubic yards or about 20 tons of broken ore. Some ore has been mined in a similar pit a short distance to the west, and several hundred feet of diamond drilling has been done. Additional development work is planned. At a distance of 600 feet to the west of the working pit is another exposure of disseminated ore that was developed by a 30-foot shaft during the war of 1914-18. A road has already been built to this, and stripping and additional development work are planned. Several other showings on the property are to be stripped and prospected. Mine equipment includes a bulldozer and portable air compressor.

In June, 1943, the mill was being operated on only one shift per day. Capacity was about 25 tons per shift on ore that assayed 10 percent Cr_2O_3. The concentrate assayed 40 percent Cr_2O_3, and had a chromium-iron ratio of 2.1 to 1. The mill is equipped with 5-foot by 4-foot ball mill, mechanically driven jig 18 inches square, and five vibrating tables. Three of these are 16 feet long, and two are 12 feet long. Plans were being made for operation of the mill on two shifts.

White Bear Mine. C. L. Best, Caterpillar Tractor Company, San Leandro, was operating this mine in June, 1943, with L. L. Huelsdonk, Downieville, in charge. It is in secs. 9, 16 T. 20 N., R. 10 E., M. D. The crew of three men had shipped seven tons of ore to Metals Reserve Company stock pile in June, 1943, and 10 tons more were ready for shipment.

TUOLUMNE COUNTY

Chromium

McCormick Property. This property in sec. 2, T. 1 S., R. 13 E., M. D., is being worked by E. A. Kent, 260 California Street, San Francisco, or P. O. Box 391, Stockton. J. V. Rice is superintendent.

Development work consists of a 30-foot winze on the 170-foot level of a 200-foot vertical shaft; also a new shaft 30 feet deep about 50 feet south of the old shaft. These operators have shipped one carload of ore and in May, 1943, had about half a carload ready for shipment running 45.15 percent Cr_2O_3 with a chromium-iron ratio of 3.45 to 1. Following is an analysis of a sample taken by Rice:

Cr_2O_3	46.74%
SiO_2	7.81
Fe	10.23
P	0.039
S	0.024
Al_2O_3	16.49
MgO	17.67

Chromium to iron ratio: 3.12 to 1, value: $49.57 per ton.

The strike of the lens is about N. 40° W., and the dip is vertical. The main lens is 65 feet long and has averaged 8 to 12 feet in width, but it pinches to a width of a few inches in places. This mine has been worked for short periods of time for many years, and these main workings are estimated to have produced a total of 5000 tons. Additional chrome ore has been produced from another working about 1000 feet to the northwest. Stopes showing on the surface are 3 to 6 feet wide and 85 feet long, but two small pillars have been left in this length. The serpentine belt in which this ore occurs is only about 200 feet wide at the mine but it widens a short distance to the south. The serpentine lies between greenstone and granodiorite. The mine has been completely mapped recently by the U. S. Geological Survey with Fred W. Cater in charge. His office is at Stanford University. The entire belt may be diamond-drilled by the U. S. Bureau of Mines.

The mine is equipped with a portable compressor and a pump, both driven by gasoline engines. A new hoist is to be installed. Considerable water must be pumped during the wet season.

Stuart and Everhart. J. F. Stuart, 1201 W. Floral Street, Stockton, or Box 241, French Camp, and G. E. Everhart, Box 210, Jamestown,

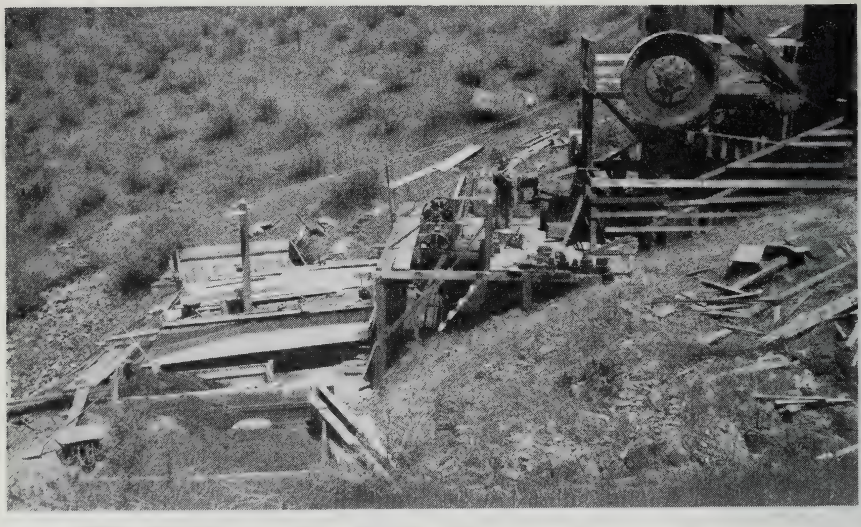

FIG. 3. Stamp mill of Stuart and Everhart, Tuolumne County.

have built a five-stamp mill on property leased by them at Peoria Flat, in secs. 25, 26, T. 1 N., R. 13 E., M. D.

The mill consists of a crusher, five stamps of 1000 pounds each, and two Wilfley tables. The stamps are driven by a 30-horsepower gasoline tractor engine. The mill was operated for a short time in 1942, and 50 tons of concentrate running 39 percent Cr_2O_3 was sold. The plant was idle during the winter but was being started again in May, 1943.

A milling grade of chrome ore is exposed in some 18 to 20 places within half a mile of the mill. Everhart states that the best showing is in a 50-foot shaft, where an 18-foot width is exposed. This was full of water at the time of our visit and was not seen. However, a trench nearby shows two bands of ore of milling grade, each 6 to 8 feet wide, with a few feet of waste between. Most of the exposures are developed by prospect holes only a few feet deep.

Quartz Crystal

Pierce Property. Quartz crystals have been found in small bunches on land owned by James Pierce, Route 1, Sonora, in sec. 28, T. 2 N., R. 14 E., M. D. The masses of crystals are about a foot in diameter and a few inches thick and occur in pockets in slate. Soft yellowish-brown clay occurs around the crystals and between some of them so that they can be separated by soaking in water. Some of the crystals seem to be clear and colorless and free from flaws. However, all of those seen were less than an inch in diameter. Pierce states that larger ones have been found, more than an inch in diameter and fully eight inches long. Hence it seems possible that further prospecting may result in the finding of more of these larger crystals. The only development work consists of shallow prospect-pits 6 feet long and 4 feet deep. Only two of these were seen.

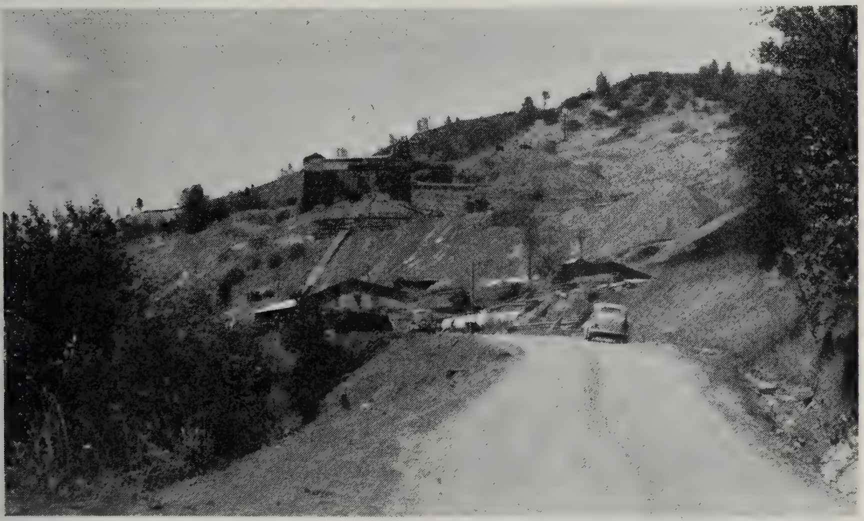

FIG. 4. Reduction plant at Reed quicksilver mine, Yolo County.

YOLO COUNTY

Quicksilver

Reed Mine.[2] Bradley Mining Company, 425 Crocker Building, San Francisco, is operating this mine, which contains 370 acres in secs. 23, 24, 25, 26, T. 12 N., R. 5 W., M. D. Charles Boyd, Monticello, is superintendent. The main road is by way of Monticello and the Knoxville mine.

Metacinnabar and cinnabar are found in a basic rock that has been serpentinized and partly silicified. The silicified material is locally called 'opaline'. The mercury minerals are found in disseminated grains throughout this silicified material and in fractures. This ore is hard. Some of the serpentine has been decomposed and cinnabar has been deposited in it. This type of ore is soft.

The main adit runs southwest for 780 feet to an ore-zone striking approximately northwest and dipping vertically. More than a thousand feet of work has been done on this zone to the northwest and about 200 feet to the southeast. Three oreshoots have been developed in this distance, each 50 to 100 feet long and 7 to 30 feet wide. At the extreme southeast end of the workings, a winze is down 180 feet all in ore. At about the center of the fracture-zone, a vertical main working-shaft goes down, and from this a drift is to be driven 700 feet to the southeast to tap the ore developed in the 180-foot winze.

About a mile and a half farther up the canyon, and several hundred feet higher in elevation than these main workings, some ore was being produced in May, 1943, from an open pit with a 1½-cubic yard power shovel, with which trucks were loaded. Several hundred feet of underground work has been done beneath this pit and some ore has been exposed. Plans call for further development of this as soon as labor is available.

Ore is treated in a Gould rotary furnace burning oil, which has a capacity of 50 to 60 tons per day. The actual amount of ore being fed to the furnace in May, 1943, was 34 tons per day. The condensing system consists of six light steel pipes and two banks of cast iron condensers of 30 each. A crew of 50 men was employed at the property.

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[2] The Department of the Interior, Geological Survey, has recently issued Information Service P. N. 31388 (December 2, 1943), *Reed Quicksilver Mine, Knoxville District, Yolo County, California;* and the following Strategic Minerals Investigations Preliminary Maps: *Reed Mine, Yolo County, California,* base map supplied by the Bradley Mining Co., geology and additional workings by Paul Averitt, G. Donald Eberlein, and E. B. Eckel, September, 1943; and *Upper Reed Tunnel, Reed Mine, Yolo County, California,* geology by Paul Averitt and G. Donald Eberlein, base map compiled from transit data supplied by the Bradley Mining Co., September, 1943. These maps are accompanied by a mimeographed report (31184) *Notes to Accompany Preliminary Maps of the Reed Quicksilver Mine, Knoxville District, Yolo County, California,* by Paul Averitt and G. Donald Eberlein.

REDDING FIELD DISTRICT

CURRENT NOTES ON THE ACTIVITY IN THE STRATEGIC MINERALS, REDDING FIELD DISTRICT

By J. C. O'Brien *

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DEL NORTE COUNTY

Chromite

Big Dipper Mine. Sec. 7, T. 16 N., R. 3 E., H. Charles Bennett, Syms Camp, and James K. Remsen, Grants Pass, Oregon, completed mining what ore was showing at this deposit.

Coon Creek Mine. Sec. 11, T. 16 N., R. 2 E. This mine was operated under lease by C. L. McClendon, Crescent City, California. Shipments were made to the stockpile at Grants Pass, Oregon.

Copper Creek Mine. Sec. 27, T. 18 N., R. 1 E., H. Operated by Gillis, Brandi, and Gillis under lease from Tyson Chrome Mines, Ltd. Shipping to Grants Pass.

Dipper Extension Claim. Sec. 28, T. 18 N., R. 2 W., H. About 10 tons of chromite has been recovered from prospect cuts and trenches on the property owned by Eugene R. Brown and Charles P. Johnson, O'Brien, Oregon. About 14 inches of chromite strikes N. 30 W. The dip is perpendicular.

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* District Mining Engineer, Redding Field District. Manuscript submitted for publication August 1943.

Eggers Chrome Claim. Sec. 29 (?), T. 18 N., R. 3 E., H. Located by I. B. Henings and D. L. Webb and leased to J. W. Eggers, O'Brien, Oregon. About 30 tons of ore has been recovered from prospect cuts and trenches. About 1¼ miles of road is being built to this property.

French Hill Mine. Secs. 5, 6, T. 16 N., R. 2 E., H. Operated by Tyson Chrome Mines, Ltd., Benjamin C. Mickle, manager. A new shaft has been sunk 59 feet on a 70° slope. The adit driven N. 50 E., 175 feet to intersect the shaft at 55-foot depth crosscut a lense which should yield several thousand tons. About 20 tons of 43 percent Cr_2O_3 is being shipped to Grants Pass per day. Sixteen men employed under C. A. Seiaroni.

Hance and Webb Property. J. A. Hance and D. L. Webb have accumulated a few tons of chromite from shallow developments on a claim in sec. 29 (?), T. 18 N., R. 3 E., H.

Judy Group. Sec. 29, T. 18 N., R. 2 E., H. Crescent Pacific Mining Company, 807 Newhall Building, San Francisco, California, have leased three claims of this group owned by R. I. Hicks of Cave Junction, Oregon. Shipping to the stockpile at Grants Pass.

High Plateau Mine. Sec. 28, T. 18 N., R. 2 E., H. Owned and operated by Eugene R. Brown, O'Brien, Oregon. A new adit has been run 200 feet in a N. 28° W. direction from a point about 100 feet east and some 40 feet lower than the portal of the old adit. A raise at the end of the new adit is connected with a 40-foot winze sloping 22° in a N. 65° E. direction. This fine deposit averages 13 to 15 feet thick over an area of more than 4000 square feet that was mined by square sets east of the old adit. About 20 tons of 53 percent Cr_2O_3 ore is being shipped to Grants Pass per day. Eight men were employed under Charles P. Johnson, superintendent.

Delbert O'Brien shipped 50 tons of coarse chromite float from the flat below this deposit.

Mountain View Mine. Sec. 35, T. 18 N., R. 1 E., H. Operated by the Tyson Chrome Mines, Ltd., Benjamin C. Mickle, manager, John Noce, superintendent, Roger L. Beals, mining engineer. A lens of chromite 17 feet thick was cut in sinking the new shaft, which is located about 300 feet west of the old shaft. The lens was cut at 47 feet but the shaft was continued in the footwall to a depth of 85 feet. The old shaft has been unwatered for a depth of 40 feet and the walls and timbers remain in first-class condition.

Muzzle Loader Claim. Sec. 4, T. 15 N., R. 3 E., H. Operated by Charles Bennett and James K. Remsen. About 5 miles of road has been built to this property. A hundred tons of 49.5 percent Cr_2O_3 ore is said to have been sent to the stockpile at Grants Pass and about 40 tons is on the dump. Four men are employed.

Theone Chrome Claim. Sec. 31(?), T. 18 N., R. 3 E., H. Donald Raymond, owner, has about 20 tons of chromite on the dumps of prospect trenches he has dug in serpentine. The red soil is quite deep and no ore has been found in place.

Toujourgai Chrome Claim. Sec. 18, T. 18 N., R. 3 E., H. Owned by D. L. Webb and H. T. Borgman. Leased and operated by F. M. Linkhart and E. H. Messenger of Kerby, Oregon.

Six to eight feet of loose rock and red soil has been stripped from an area 100 feet square above a flat lens of chromite 1 to 2 feet thick. This deposit was formerly worked through an adit running due north for 80 feet. An outcrop of what is probably the same lens has been uncovered about 250 feet east. A new deposit striking N. 40° E. and dipping slightly east was exposed on the north side of the area stripped for a length of 35 feet. About 125 tons of 50 percent Cr_2O_3 ore is said to have been hauled to the stockpile at Grants Pass, Oregon.

Victory No. 2, Judy Group. Sec. 29, T. 18 N., R. 2 E., H. Two claims of this group are being worked by R. I. Hicks, of Cave Junction, Oregon, owner. Shipments are made to Grants Pass.

Quicksilver

Webb Cinnabar Claim. Sec. 18, T. 18 N., R. 3 E., H. Bert Avery has leased this property from H. C. Wilmot and is installing two 12-inch-diameter steel pipe retorts, 7 feet long. About 100 tons of ore on the dump is said to average 10 pounds of mercury per ton. Native quicksilver and cinnabar occur in seams and vugs in a gray andesitic rock which has been explored by short drifts and crosscuts to the southwest of an adit, and from the bottom of a 35-foot shaft near the portal. Some of the ore is very rich in native quicksilver.

HUMBOLDT COUNTY

Chromite

Big Rock Chrome Claim. Sec. 24(?), T. 10 N., R. 5 E., H. J. L. Woodehouse, Orleans, owner. Two men are screening and sorting coarse chromite from a gravel deposit. The ore is hauled 97 miles by truck to the stockpile at Arcata.

Man-O-War Chrome Claim. Sec. 13, T. 11 N., R. 4 E., H. J. K. Griffith's Mining and Development Company operating under lease from Joe Rivers and Roy McGain, owners. A shaft was sunk 30 feet on a chimney of chromite that was 30 to 40 inches wide in places. Five men were employed in May 1943.

Mosquito Lake Chrome Mine. Sec. 11, T. 11 N., R. 4 E., H. Owned by Llewellyn O. Wilder and son of Orleans. A road has been built to this deposit from the Cedar Camp trail and shipments made to the stockpile at Arcata.

Rivers Chrome Mine. Sec. 13, T. 11 N., R. 4 E., H. Owned by Joe Rivers and Michael Reddy. Operated by Mrs. Dorothea Reddy Moroney. A lens of chromite was mined through an incline shaft about 90 feet deep in a N. 22° W. direction and dipping from 10 to 15 degrees. It was mined for an average width of about 25 feet. Five men were employed in May 1943 under K. W. Walters, superintendent. The mine was reported to have been purchased by Dwight Pettigrew and Harry Lucas of Sacramento in June 1943.

Signal Peak Chrome Claim. Sec. 36, T. 1 S., R. 5 E., H. C & R Mining Company, 703 Market Street, San Francisco is reported to have leased this property from A. C. Crossman and associates, Zenia, California.

Copper-Zinc

Copper Bluff Lease. Sec. 2, T. 8 N., R. 4 E., H. This property is located on the Hoopa Indian Reservation and is leased to A. W. Scott of Happy Camp. Shallow shafts and trenches disclose a 7-foot vein in a pyritic schist striking N. 5° W., dipping 46° E. Cut samples from exposures along a 4000-foot length are said to average 5 percent copper, 14 to 17 percent zinc, 8 to 50 ounces of silver, $5.80 gold and 0.5 to 1.5 percent lead.

Manganese

Bear Ridge Manganese Claim. Sec. 25, T. 1 S., R. 5 E., H. The C & R Mining Company is reported to have leased this property from A. C. Crossman and associates of Zenia, California.

Fort Seward Mine. Sec. 15, T. 3 S., R. 4 E., H. Operated by James C. Warren, San Francisco. Five men employed under Joe Lopez mining manganese from bulldozer cuts. Shipping to Sacramento.

Woods Mine (Charles Mountain). Sec. 2, T. 1 S., R. 4 E. James C. Warren, of Sacramento, was preparing to reopen this deposit in June 1943.

PLUMAS COUNTY

Chromite

Blue Jay Chrome Mine. Secs. 31, 32, T. 26 N., R. 7 E., M. D. C. L. Gander and Tom Ormand of Belden mined small bunches of chromite from shallow pits and trenches in peridotite.

Cattle Springs Group. Sec. 8, T. 23 N., R. 9 E., M. D. Jack Malone is building a road to this property which he has leased from E. R. Spivey and E. R. Patterson.

Commander Claim. Sec. 17, T. 23 N., R. 9 E., M. D. Robin R. Jesky and Jake Morozzio built about a mile of road and worked small kidneys of chromite in serpentine with open cuts and an adit run N. 20° W. for 40 feet.

White Pine Group. Five claims in sec. 17, T. 23 N., R. 9 E., M. D. E. R. Patterson and E. V. Spivey owners. Prospecting and mining is done by digging trenches in the deep red soil with bulldozers. A kidney of chromite in White Pine No. 1 claim, 16 feet long and 10 feet wide, yielded 400 tons of 52 percent Cr_2O_3 ore to a depth of 25 feet and still shows across the bottom of the trench. Several other outcrops on this group of claims remain to be developed.

Manganese

Haunganese Mine. Sec. 13, T. 25 N., R. 8 E., M. D. Owned by Henry H. Haun and Robert Holstrom of Quincy. Leased to George Usher of Oakland. A vein of manganese oxide from 30 inches to 6 feet wide strikes N. 75° W. and dips 66° N. Four men are employed mining the ore through adits. Shipping to the stockpile at Quincy.

High Grade Manganese Claims No. 1-2. Located on a logging road near old Taylor Lake. Owned by John Sobrero and George Stevens and leased to Western Manganese Mines Company, Crescent Mills. Two men employed trenching the outcrop.

Western Manganese Mines Co. (Braito Mine). Sec. 26, T. 26 N., R. 9 E., M. D. Leased and operated by O. H. Griggs and associates, Crescent

Mills. Producing 12 to 15 tons of 46 percent Mn ore per day developing a 4- to 12-foot vein striking N. 35° W. This vein can be traced by old adits and trenches for about 1000 feet.

SHASTA COUNTY

Chromite

Little Castle Creek Mine. Sec. 2, T. 38 N., R. 4 W., M. D. L. H. and M. M. Brown, Dunsmuir, have 5 men employed. Disseminated and massive chromite occurs in a tan and lemon colored dunite in a cut about a hundred feet higher than the old adit level and extending about 100 feet in a S. 40° E. direction. Producing 12 to 15 tons of 37 percent Cr_2O_3 ore per day. They are planning to send low-grade material to the chrome concentrator at Castella operated by the Montrose Mining and Milling Company.

Lucky Strike Claim. Sec. 7, T. 38 N., R. 4 W., M. D. Philip Munko and L. D. Taylor, Dunsmuir, owners. A road has been bulldozed to this deposit which outcrops 15 feet wide for a length of 20 feet. Shipping to the stockpile at Yreka.

Montrose Mining and Milling Company. Max Schmidt, president. Operating a 150-ton gravity concentrator on low-grade chrome ores in the Castella area. Concentrating with jigs and Wilfley tables.

Round Bottom Chrome Mining Claim. Sec. 4, T. 28 N., R. 10 W., M. D. Owned by Dave and John Pierson. Leased and operated by Donald Woodrum of Redding. A flat lens of chromite 6 inches to 9 feet thick was mined from an area 40 feet square east of an incline shaft 75 feet deep. Shipments were made to Sacramento.

Union Forest Queen Mine. Sec. 22, T. 37 N., R. 5 W., M. D. Six claims, owned by Antone Orsini of Redding. Leased to the Montrose Mining and Milling Company. Small lots of chromite left on the dumps from former operations were hauled to the mill at Castella.

Copper-Zinc

Mountain Copper Co., Ltd. Secs. 34, 35, T. 33 N., R. 6 W., M. D. A 350-ton flotation plant situated near the portal of the Hornet mine was put into operation recovering copper and zinc concentrates from ore developed in the Hornet mine.

Iron

Shasta Iron Co. Sec. 26, T. 34 N., R. 4 W., M. D. Leased and operated by Lee Carrico and Melvin Gautier. Three power-shovels were employed stripping and mining magnetite. The ore is screened and sized at the Hein Brothers plant in Redding and shipped to the Bay area.

Pyrite

Hornet Mine. Sec. 35, T. 33 N., R. 6 W., M. D. The Mountain Copper Company, Ltd. continued shipping several hundred tons of pyrite per day to their plant at Martinez.

SISKIYOU COUNTY

Chromite

Constable and Foster Claims. Sec. 36, T. 42 N., R. 7 W., M. D. Hugh Williamson of Yreka leased these claims and mined a 2- to 3-foot lens of chromite by open cut and adit for a length of about 80 feet. He built about a mile of road and hauled his ore to the Yreka stockpile.

Barkhouse and Whiskey Boy Claim. Sec. 11, T. 46 N., R. 12 W., M. D. Owned by A. Lowden and leased to K. W. Walters of Happy Camp. About 30 tons of chromite was mined from shallow cuts in serpentine.

Black Crow Claim. Sec. 20, T. 38 N., R. 11 W., M. D. Tom Eldridge of Cecilville has uncovered two outcrops of chromite and is building an ore bin on the Crawford Creek road. Shipments will be made to Yreka.

Coggins Mine. Sec. 35, T. 39 N., R. 4 W., M. D. Leased and operated by James K. Remsen of Grants Pass, Oregon. This deposit was mined through an adit 212 feet long in a N. 17° W. direction. Broken, shifting ground required heavy timbering. A winze 18 feet deep was in waste with a stringer of chromite showing. A total of 1976 tons of chromite said to average $32-$33 per ton were shipped to Sacramento from this property in 1942-1943.

Cyclone Gap (Mammoth Mine). Sec. 15, T. 17 N., R. 5 E., M. D. Operated by James K. Remsen of Grants Pass, Oregon. Eight men are employed under Ben Baker, superintendent, sinking the vertical winze which showed an 8-foot lens of chromite striking S. 70° E. and dipping 70° N. at 26 feet below the adit level and some 80 feet below the outcrop. Producing about 5 tons of 43 percent Cr_2O_3 ore per day. Hauling 60 miles to Grants Pass.

Fairview Chrome Mine. Sec. 27, 34, T. 46 N., R. 11 W., M. D. F. S. Pollak, Washington, D. C., owner. H. E. Ellickson, manager, Yreka. The old open cuts have been timbered and the chromite is now being mined through adits and stopes. A lens of good ore was cut on the west side of the mountain while grading for a road. Fifteen men employed under William Winters, foreman, produce about 90 tons of 35 to 38 percent Cr_2O_3 ore per week.

Genesis Claim. Sec. 2, T. 41 N., R. 7 W., M. D. Owned by R. V. and Ernest Hayden, C. T. Thompson. Small lenses of chromite occur in serpentine.

Ernest Hayden reported that a shaft on railroad sec. 35, T. 42 N., R. 7 W., M. D., continues in 50 percent Cr_2O_3 ore at a vertical depth of 105 feet. Shipping to Yreka stockpile.

Kangaroo (Kubli) Chrome Claim. Secs. 12-13, T. 47 N., R. 12 W., M. D. A road is being built to this deposit owned by the Kangaroo Mountain Chrome Company.

Ladd (Red Mountain) Chrome Mine. Sec. 15, T. 46 N., R. 11 W., M. D. The U. S. Forest Service built 4 miles of road from the Seiad bridge to this deposit. Under lease to Ronald Knudsen of Yreka. Banded and disseminated chromite is mined from adits and open cuts. A gravity tram 150 feet long has been built to the hundred-ton-capacity ore bin at the road. Four men employed.

Lake Claims. Luther Lake, Cecilville, has leased 8 claims in Dry Gulch, sec. 20, T. 38 N., R. 11 W., M. D., to Otto Hueffner of San Francisco. About 50 tons of chromite has been mined from shallow surface diggings.

Peg Leg (Lambert) Chrome Mine. Sec. 25, T. 44 N., R. 8 W., M. D. Owned by Basil Wild and Carl Johnson, Fort Jones, and leased to C. F.

Shaw of Yreka. Three men stoping a flat lens, 10 inches to 3 feet wide, beneath a clay gouge. Ore is reported to assay 52 percent Cr_2O_3. Shipping to Yreka.

Seiad Chrome. Secs. 7, 17, 18, 19, 20, T. 47 N., R. 11 W., M. D. This property has been leased to the Kangaroo Mountain Chrome Company by the Rustless Mining Corporation, owners. Three men employed mining a banded type of chrome ore in dunite, from open cuts.

Snowy Ridge Chrome Claim. Sec. 21, T. 48 N., R. 9 W., M. D. Leased and operated by James K. Remsen of Grants Pass, Oregon. Shipping to the stockpile at Grants Pass, Oregon.

Wild and Johnson Property. Basil Wild and Carl Johnson of Fort Jones leased sec. 19, T. 42 N., R. 8 W., M. D. Mined shallow lenses in serpentine with a bulldozer. Ore shipped to the Yreka stockpile is said to have averaged 53 percent Cr_2O_3.

Copper

Gray Eagle Mine. Sec. 4 et al., T. 17 N., R. 6 E., H. The 600-ton flotation plant built by the Newmont Mining Corporation was put into operation in March. The National Housing Authority is building houses at Happy Camp for the employees.

Polar Bear Mine. Sec. 12, T. 40 N., R. 8 W. Winters and Heath had 9 men employed. They had retimbered 36 feet of a two-compartment shaft said to be 210 feet deep, and had reopened an old adit driven 120 feet west to a 4-foot vein in serpentine, striking N. 50° W. The ore was largely pyrite with some chalcopyrite and occasional bunches of sooty chalcocite in seams and vugs. The property was closed in March.

Graphite

Elk Lake Graphite (Crystal) Mine. Sec. 7, T. 47 N., R. 11 W., M. D. Owned by W. B. and Elwood Stewart of Etna. Flake graphite occurs in thin seams and disseminated in sandstone on the east slope of Red Mountain and west of Elk Lake. The property has been prospected for about 3000 feet in a N. 25° W. direction, by shallow trenches and pits.

Quicksilver

Empire Canyon Mining Company (Great Northern). Sec. 13, T. 47 N., R. 8 W., M. D. Edward Webber, Box 217, Yreka, is reported to have purchased this property from Byron W. Burch of Seattle. Native quicksilver and cinnabar occur in vugs and seams in calcite. The ore is treated in a 25-ton Nicholas-Herreshoff furnace.

TEHAMA COUNTY

Chromite

Blue Sky Chrome Claim. Sec. 17, T. 28 N., R. 9 W., M. D. H. A. Robinson and H. T. Moore of Platina have about 40 tons of chromite mined from open cuts in serpentine.

McLaughlin and Applegarth Property. Frank Y. McLaughlin and George A. Applegarth, 3001 Russ Building, San Francisco, are leasing secs. 9, 16, 17, 21, T. 25 N., R. 7 W., M. D. Mining lenses of shipping-grade ore in serpentine by open cut in section 17 and prospecting the large low-grade areas.

TRINITY COUNTY

Chromite

Black Crow Claim. Sec. 18, T. 38 N., R. 5 W., M. D. Owned and operated by George L. Costa, Castella, who had some ore ready to ship when the snow cleared, in April 1943.

Sunny Slope Claim (Collins). Sec. 10, T. 29 N., R. 11 W., M. D. Owned by Joe Sauer and Fred Cole of Redding. About 30 tons of ore on the dump from development work. Lenses in serpentine and disseminated ore in dunite.

Manganese

C. and R. Mining Company. This company, 703 Market Street, San Francisco, is reported to have leased the Black Oak manganese claim from A. C. Crossman and associates of Zenia. Located in sec. 5, T. 3 S., R. 6 E., H.

Coldwater No. 1 (White Estate). Secs. 8, 9, T. 4 S., R. 6 E., H. Leased to Ray Helmke, Alderpoint. Black manganese oxide kidneys in shale mined with a bulldozer. Preparing to drive an adit on a vein in the bottom of the pit, striking S. 20° W.

Manganese Queen. Sec. 25 or 36, T. 30 N., R. 12 W., M. D. Owned by Charles H. and Bessie J. Crews of Hayfork. Leased and operated by A. Granzotto Construction Company, Lafayette, California. A vein of manganese oxide and carbonate, 4 to 15 feet wide striking N. 55° W., dipping 55° SW, is mined by open cut. Shipping about 20 tons per day to the stockpile at Anderson.

McNight Manganese Mine (Blue Jay). Sec. 17, T. 26 N., R. 12 W., M. D. Leased to James I. Scott & Company, Fortuna. A 3 to 6 foot vein of manganese oxide and carbonate ore is mined from three adits. The veins strike northwest and dip about 65° NE. Shipping to Sacramento.

Shellview Claim. Sec. 4, T. 4 S., R. 6. E., H. Leased to Ray F. Helmke, Alderpoint. Three men employed under Jim Larson, foreman, driving an adit N. 27° E. to prospect beneath an area that yielded small kidneys of manganese oxide and carbonate ore in schist.

Quicksilver

Altoona Quicksilver Mining Company. Secs. 22, 26, 28, T. 38 N., R. 6 W., M. D. The Marsman Company of California, 2504 Russ Building, San Francisco, are reported to have purchased a substantial interest in this property and increased production is expected.

Tungsten

Clerbus Mae Mine. Sec. 31, T. 9 N., R. 8 E., H. Owned by Burtt L. Berry and James Roby. A small amount of scheelite occurs in a 2- to 3-inch quartz vein in a granitic rock.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins *

In This Issue

Persons interested in new minerals and in mineralization of contact-metamorphic zones will be pleased to read *Crestmore Minerals,* by A. O. Woodford, an up-to-date paper on one of the most famous mineral localities of the world.

Structural geology is a three-dimensional study; maps drawn on only two dimensions do not properly express this fact. In complex mining geology, models are often constructed to show graphically these features. Models, however, are three-dimensional objects in themselves, and are too bulky and expensive to transport or copy. The answer to the problem is a drawing in perspective. The *Isometrograph,* as described by J. McLaren Forbes, is a fairly simply constructed instrument designed by him to assist in the drawing of block diagrams. It was built in a mine shop, and it has proved its usefulness in the construction of a complicated diagram of the New Idria quicksilver mine.

A paper by Walter Stalder, *Notes Relating to Sutter (Marysville) Buttes Gas Field,* appears in this issue of the Journal. The author was "inspired by a paper presented by Mr. Harry R. Johnson" in Bulletin 118, pages 610 to 615.

Recent Publication

Bulletin 118, *Geologic Formations and Economic Development of the Oil and Gas Fields of California,* has recently been issued in its final bound form. It is comprised of four parts:

PART ONE —Development of the Industry
PART TWO —Geology of California and the Occurrence of Oil and Gas
PART THREE—Descriptions of Individual Oil and Gas Fields
PART FOUR —Glossaries, Bibliography, and Index

Many letters of congratulation have been received, showing that the usefulness of this timely book is recognized and highly appreciated.

In Press

Bulletin 125, *Manganese in California,* will soon be completed. It is comprised of six separate papers, each contributed by an authority. Accompanying the bulletin is a large map of the state, which shows the locations of all known deposits, classified according to production of manganese ore. In the margin of the map are various charts, diagrams, maps, and descriptions on geology, economics, mining, etc. Contents of Bulletin 125 are:

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* Chief Geologist, State Division of Mines.

Preface, by Olaf P. Jenkins
History of the Manganese Industry, by Robert Scott Kroger
Occurrence and Minerals of Manganese, by Theo H. Crook
Utilization of California Manganese Ores, by O. Cutler Shepard
Manganese Deposits of California—A Summary Report (including Tabulated Data on Manganese Properties of California), by Parker D. Trask, Ivan F. Wilson, and Frank S. Simons
Genesis of the Manganese Deposits of the Coast Ranges of California, by N. L. Taliaferro and F. S. Hudson
Manganese Deposits of the Sierra Nevada, Their Genesis and Metamorphism, by N. L. Taliaferro
Outline Geologic Map of California Showing Locations of Manganese Properties, by Olaf P. Jenkins

In Preparation

W. J. Miller, Professor of Geology, University of California at Los Angeles, has in preparation three geologic papers that will appear in a forthcoming issue of the Journal. These are *Geology of Barstow Quadrangle, Geology of Needles-Goffs Area,* and *Geology of Area from Palm Springs to Blythe.*

It has been tentatively planned that the results of geological investigations of the iron ore deposits of California, recently made by the staff of the Geological Survey, United States Department of the Interior, will be published by the Division of Mines.

Geologic investigations of copper deposits of California are now being carried on by the Federal Survey. The Geologic Branch is cooperating in this study by preparing *Economic Mineral Map of California, No. 6—Copper.* This map will be one of a series, part of which has already been issued. The five maps previously issued are: No. 1, Quicksilver; No. 2, Oil and Gas; No. 3, Chromite; No. 4, Tungsten; No. 5, Manganese (in press). These maps are all companions to the Geologic Map of California (1938), for the base is a reduction of the larger master map.

CRESTMORE MINERALS

By A. O. Woodford *

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ABSTRACT

At Crestmore, near Riverside, limestone contact zones and intrusive plutonic and dike rocks contain an unusually large number of mineral species, more than 100 of which have been identified. The minerals and their relationships have been exposed by the quarrying and mining operations of the Riverside Cement Company.

In the contact zones the most abundant minerals are garnet, diopside, idocrase, wollastonite, monticellite, and spurrite, the last named as a principal constituent of a fine-grained rock which also includes monticellite and other minerals. Nine new species have been described from Crestmore, all as primary or secondary constituents of the contact zones. These minerals are wilkeite, crestmoreite, riversideite, plazolite, jurupaite, merwinite, foshagite, tilleyite and ellestadite.

In the limestone beyond the contact zones, disseminated brucite grains are locally abundant and graphite flakes are more rarely present.

The pegmatites, especially those associated with the relatively small masses of intrusive quartz monzonite porphyry, have some unusual constituents, such as laumontite and other zeolites, andradite garnet, axinite, thulite, the rare-earth mineral allanite and the thorium-bearing ''Mineral L.''

Something as to the nature and intensity of the metamorphism is indicated by the close association of the silicate contact rocks with pegmatites, by the contamination of the fine-grained porphyry at and near limestone contacts, by the absence of dolomite and tremolite from the crystalline limestone, and by the presence in the contact zones of diopside, wollastonite, monticellite, spurrite, and merwinite.

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* Professor of Geology, Pomona College, Claremont, California. Manuscript submitted for publication November 1, 1943.

INTRODUCTION

A cement plant was started in 1909 at Crestmore, near Riverside, 50 miles east of Los Angeles (fig. 1). Crystalline limestone and other rocks were quarried from the twin Crestmore Hills for use in the manufacture of cement and for other purposes.

In 1914 Professor A. S. Eakle of the University of California called the attention of mineralogists to the numerous contact minerals which were being found at this promising locality. In the next two or three years Professor Eakle, Professor A. F. Rogers of Stanford, Mr. R. M. Wilke of Palo Alto, and especially Mr. L. J. Childs of Rialto, collected many fine specimens of grossularite, diopside, wollastonite, idocrase, and other minerals from the limestone contact zone. In 1914 Eakle and Rogers described the complex new mineral wilkeite, in 1917 Eakle published a general paper on the locality, and in 1918 Rogers reported periclase. The first period of good collecting came to an end in 1916 or 1917.

Important Crestmore discoveries were made by W. F. Foshag and E. S. Larsen in the twenties, including spurrite, thaumasite, centrallasite and the new minerals merwinite and plazolite. In the thirties M. A. Peacock distinguished parawollastonite, using Crestmore material, Duncan McConnell reported on members of the apatite group, recognizing ellestadite as a new end-member, and Larsen and Dunham described the new mineral tilleyite.

In 1938 new quarrying in the principal contact zone exposed not only minerals previously listed from the locality, but also many others. Part of the new finds are from the limestone contact and part are from the white dikes of intrusive pegmatite. A report on these finds was made in the American Mineralogist (Woodford, Crippen, and Garner, 1941). The present paper adds a little new information, and is devoted especially to the minerals as such.

ACKNOWLEDGMENTS

Much of the text and several illustrations from the 1941 report are incorporated in the present paper, through the courtesy of Messrs. Crippen and Garner, and the American Mineralogist by its editor, Professor W. F. Hunt.

The officers of the Riverside Cement Company have been most courteous and generous, furnishing base maps and much information. I am especially indebted to Garner A. Beckett, president of the company, Howard R. Starke, superintendent, and R. H. Wightman, engineer. Mr. Wightman furnished the information concerning quarrying and mining operations, and aided in many other ways.

Two other persons, Dr. Edgar H. Bailey (now of the U. S. Geological Survey) and Richard E. Strehle (now a lieutenant in the U. S. Army) aided greatly in the collecting and study of the Crestmore minerals. Their contributions can hardly be overestimated. Professor Adolf Pabst of the University of California (Berkeley) furnished a valuable specimen from the Eakle collection; he and Mr. W. H. Dore of the University kindly made X-ray determinations and calculations on treanorite (allanite). Dr. Waldemar Schaller of the U. S. Geological Survey wrote a letter of comment on the 1941 paper by Woodford, Crippen, and Gar-

ner; his suggestions were much appreciated and have been incorporated in the present paper as far as possible.

Specimens or information were also received from Mrs. R. A. Crippen, R. E. Campbell of Bloomington, M. P. Yackel (geologist for the Riverside Cement Company in 1941 and 1942), Professor Joseph Murdoch of the University of California (Los Angeles), Jewell J. Glass of the U. S. Geological Survey, Dr. Gustav Albrecht and Mr. Philip A. Vaughan of the Pomona College Chemistry Department, Raymond Alf of the Webb School of California, Dr. J. W. Eggleston of Riverside and Vermont, Howard Small of Riverside, Professor H. Stanton Hill of Pasadena Junior College, and Melvin Swinney (now of the U. S. Geological Survey). Messrs. Swinney, Yackel, Hill, Vaughan, and Alf furnished some laboratory data. John S. Shelton kindly criticized the manuscript.

Most of the spectrographic and chemical determinations were made by Dr. T. G. Kennard, David Howell, and J. D. Laudermilk of the Claremont Colleges. The chemical analysis of treanorite (allanite) was made by R. B. Ellestad of the University of Minnesota.

I am indebted to Claremont Colleges for a research grant.

I have personally checked almost all the field and optical data here recorded.

QUARRYING AND MINING AT CRESTMORE

In the early days of the operation at Crestmore, limestone was obtained from quarries at the site, silicate rock was excavated from a "Commercial quarry" to be used for road metal and other purposes, and clay for cement manufacture was brought from a distance. At the time when mineralogists first became interested in the place, there were five or six surface quarries. Those on or near the southwestern or Chino Hill were called the Chino quarries. On the northeastern or Sky Blue Hill there were at the east the large Commercial quarry which yielded both limestone and silicates, and at the north and northeast the high-level Lone Star quarry and the rather shallow pit of the Wet Weather quarry. In 1927 the lower Chino quarries had been cut down to the general level of the country or somewhat deeper, and at that time a mine was commenced which was completed in 1930. Since 1930 limestone has been mined beneath a large part of the earlier Chino quarries, resulting in the formation and growth of a glory hole where these quarries had been previously (fig. 2). Long before 1930 Crestmore granodiorite or quartz diorite had been substituted for the clay previously brought from a distance. From 1930 until late in 1939 the mine furnished all the plant's requirements of limestone and "clay." Since 1939 about half the production has been from the mine, the other half coming from Wet Weather (and Lone Star) quarry or from more distant sites not shown in figure 2. Development of the mine consists of approximately 8 miles of drifting and 5 miles of raising. The system used is commonly known as the block-caving method. Probably this is the only limestone mine using this method of recovery, although there are other underground limestone mines. At the present time hundreds of thousands of tons of rock are removed yearly from the Crestmore mine and quarries.

GENERAL GEOLOGY OF CRESTMORE

There are exposed at Crestmore crystalline limestone and other metamorphosed sediments, enveloped in and cut by intrusive igneous rocks. The limestone is coarsely crystalline, with calcite grains usually 3 or 4 millimeters, and occasionally 15 to 30 millimeters, in diameter. This rock is similar to that at numerous other localities in the vicinity and in the San Bernardino and eastern San Gabriel Mountains (fig. 1). The age of the limestone is probably Upper Paleozoic, as fossils which have been referred to the Mississippian have been found at two widely separated localities.[1] The limestones that are now found in the vicinity of Riverside are relatively small roof pendants preserved in an enveloping and intrusive quartz diorite or granodiorite, with or without other finer grained intrusives. Quartzite, either pure or micaceous, is commonly associated with the limestone remnants. At several localities extensive suites of contact metamorphic minerals have been developed in the limestones. The contact metamorphic assemblages are much the same at Victoria and other quarries in the city of Riverside, at Crestmore, and at Cascade Canyon in the San Gabriel Mountains. However, most of the rarer Crestmore minerals are not found at the other localities.

At Crestmore (fig. 2) the limestone occurs as two irregular, very roughly parallel, lenticular bodies whose principal portions dip as much as 45° E. or ENE. The prevalent north or north-northwest strike conforms to the trend of the Peninsular Range to the south, and is almost perpendicular to that of certain other metamorphic rocks near Riverside, suggesting that this region is one of structural transition to the westward-trending strikes prevalent at Cascade Canyon and elsewhere in the Transverse Ranges to the north. The lower (western) limestone body

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[1] Woodford, A. O., and Harriss, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, California: California Univ., Dept. Geol. Sci., Bull. 17, pp. 265-304, 1928. (Furnace limestone.)

Webb, R. W., Evidence of the age of a crystalline limestone in southern California: Jour. Geology, vol. 47, pp. 198-201, 1939. (Winchester magnesite mine.)

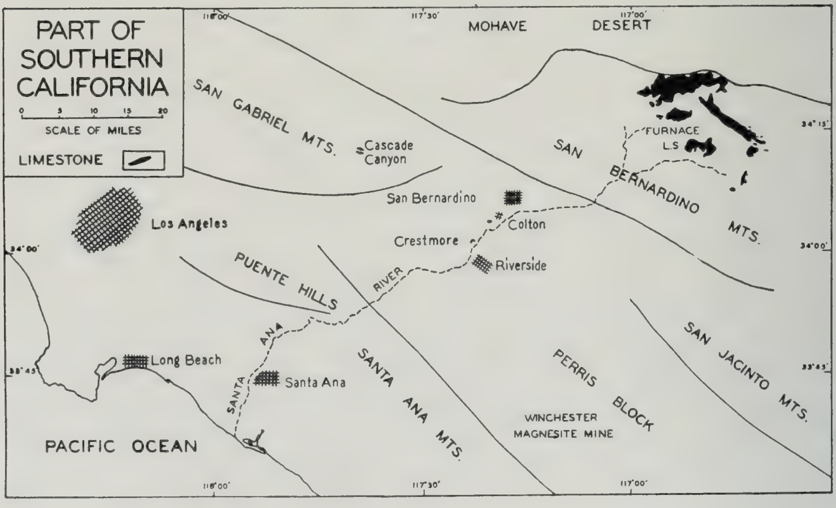
PART OF
SOUTHERN
CALIFORNIA
0
5
10
15
20
SCALE OF MILES
LIMESTONE
118°00'
117°30'
117°00'
MOHAVE
DESERT
34°15'
34°00'
33°45'
SAN GABRIEL MTS.
Cascade Canyon
SAN BERNARDINO MTS.
FURNACE L.S
San Bernardino
Colton
Crestmore
Riverside
Los Angeles
PUENTE HILLS
RIVER
SANTA ANA
Long Beach
Santa Ana
SANTA ANA MTS.
PERRIS BLOCK
SAN JACINTO MTS.
WINCHESTER MAGNESITE MINE
PACIFIC OCEAN

Fig. 1. Index map of a portion of southern California, showing some of the areas of crystalline limestone. *Courtesy American Mineralogist.*

at Crestmore is overlain by a thin, discontinuous band of quartzite or quartz-mica schist and there are other highly siliceous masses not far away. The lower lens is commonly called the Chino limestone. It is relatively pure. The upper (eastern) lens is sometimes, but not always, called the Sky Blue limestone. It is intruded by large bodies of quartz monzonite porphyry as well as by the enveloping quartz diorite. The porphyry is of variable composition and texture, and probably has been contaminated by the assimilation of limestone or in other ways. Numerous large and small pegmatite masses and dikes are present in the quartz monzonite porphyry and extend into the adjacent rocks, especially into the great masses of garnet-rich contact rocks which have developed from the original limestone.

The Chino quarry and an extensive mine have been excavated in the Chino limestone. The Commercial, Wet Weather, and Lone Star quarries are in Sky Blue limestone and also penetrate the adjacent contact rock and quartz monzonite porphyry. The relative positions of mine and quarries are shown in figure 2.

Chino Limestone

The Chino Hill limestone of Eakle (4), called Chino quarry limestone by Daly (19), has been well described lithologically by these authors. It is typically composed of bands a few inches or a few feet thick of alternating coarse white crystalline limestone and somewhat yellowish predazzite. Graphite flakes are widely disseminated through the limestone but are far from universal. The brucite in the predazzite is pseudomorphic after octahedral periclase. The grains of brucite are commonly 1 to 2 millimeters across and are surrounded by still larger anhedrons of calcite, making a rock which is considerably coarser grained than the type predazzite, but otherwise very similar in appearance.

The Chino limestone lens dips up to 45° E., is at least 2000 feet long, and extends down the dip at least 1200 feet (to sea level). The upper and lower surfaces are both uneven. The maximum thickness has proved to be about 300 feet. Practically the whole original outcrop of the Chino limestone has now been removed by quarrying and mining operations and its site is marked by a glory hole 200 feet deep in the center.

Sky Blue Limestone

The upper or Sky Blue limestone has an arcuate outcrop, as indicated by the positions of the Lone Star and Wet Weather quarries and the portion of Commercial quarry which has been cut down to 910 feet elevation (fig. 4, map). The observable suggestions of bedding dip mostly east or northeast (southeast in Lone Star). Apparently the limestone was several hundred feet thick in Wet Weather quarry, but it thins to almost nothing between Wet Weather and the 910-foot level, the limestone beds here having been largely converted into contact rock (fig. 3).

The structure of the limestone is uncertain. It may be a nearly isoclinal fold, with a longer east-dipping limb extending south through the 910-foot level, and a shorter southeast-dipping limb marked by the shallow, high-level southwest extension of Lone Star quarry (not shown in fig. 3).

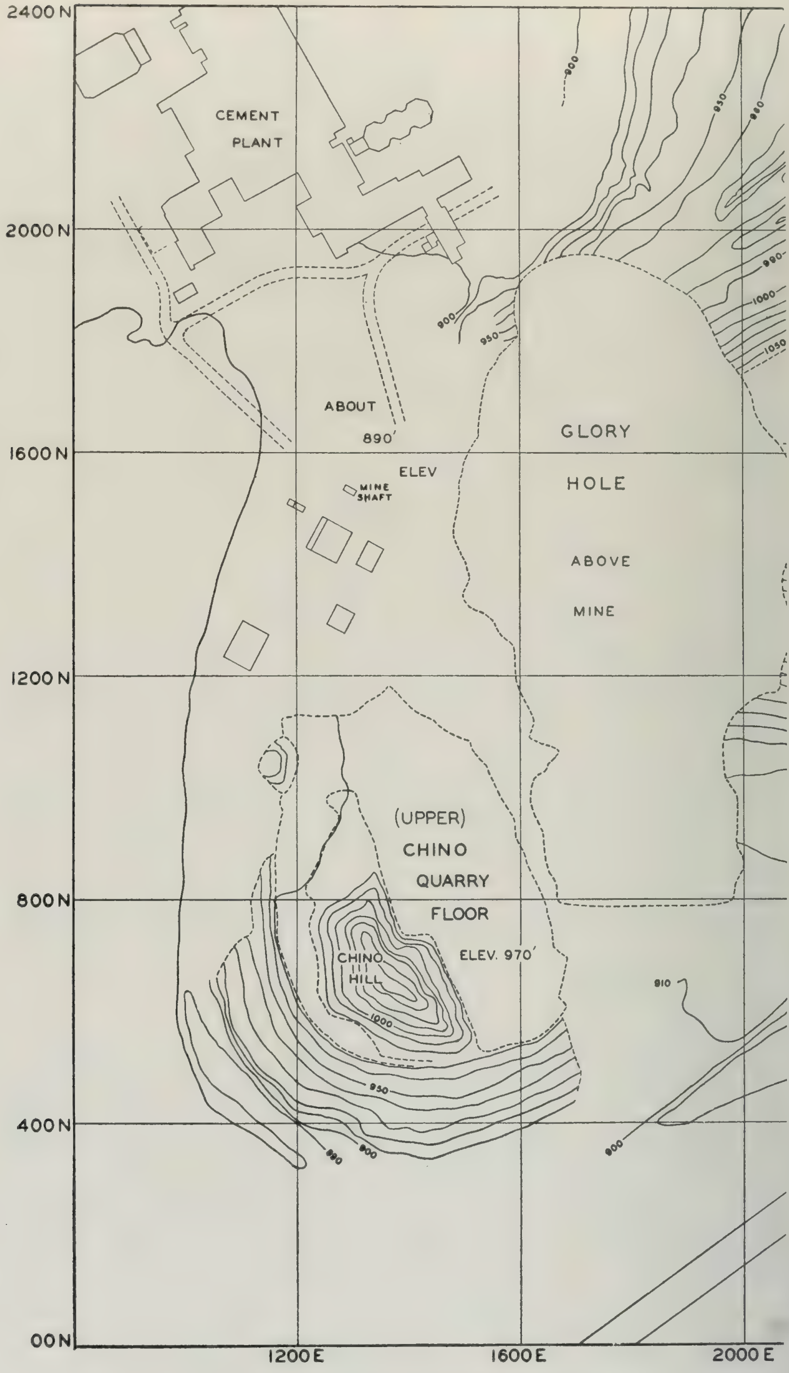
2400 N
2000 N
1600 N
1200 N
800 N
400 N
00 N
1200 E
1600 E
2000 E
CEMENT PLANT
900
950
980
990
1000
1050
900
950
ABOUT 890' ELEV
MINE SHAFT
GLORY HOLE ABOVE MINE
(UPPER) CHINO QUARRY FLOOR
ELEV. 970'
CHINO HILL
1000
950
910
890
900
900

Fig. 2. Map of Crestmore quarries, 1943.

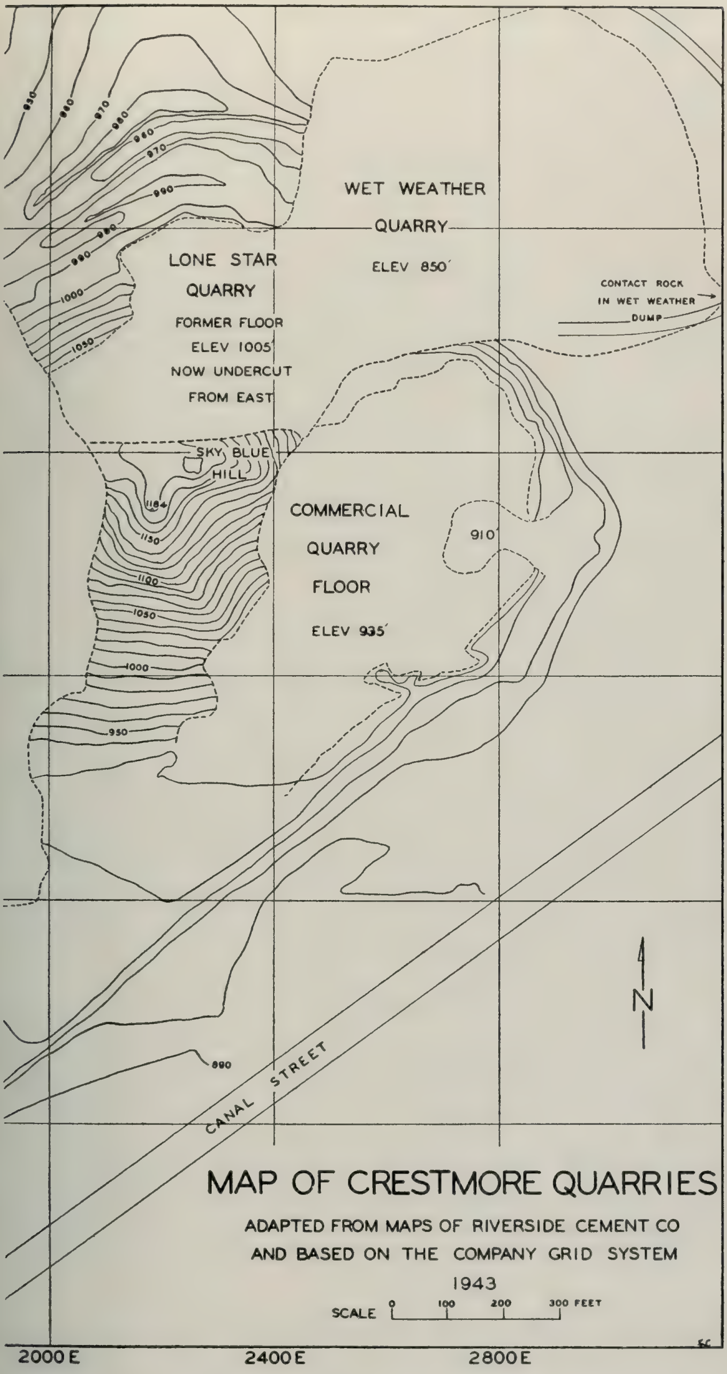
950
960
970
980
960
970
990
980
990
1000
1030
WET WEATHER
QUARRY
ELEV 850′
LONE STAR
QUARRY
FORMER FLOOR
ELEV 1005′
NOW UNDERCUT
FROM EAST
CONTACT ROCK
IN WET WEATHER
DUMP
SKY BLUE
HILL
1184
1150
1100
1050
1000
950
COMMERCIAL
QUARRY
FLOOR
ELEV 935′
910′
890
CANAL STREET
N
MAP OF CRESTMORE QUARRIES
ADAPTED FROM MAPS OF RIVERSIDE CEMENT CO
AND BASED ON THE COMPANY GRID SYSTEM
1943
SCALE 0 100 200 300 FEET
2000E
2400E
2800E

FIG. 2. Map of Crestmore quarries, 1943—Continued.

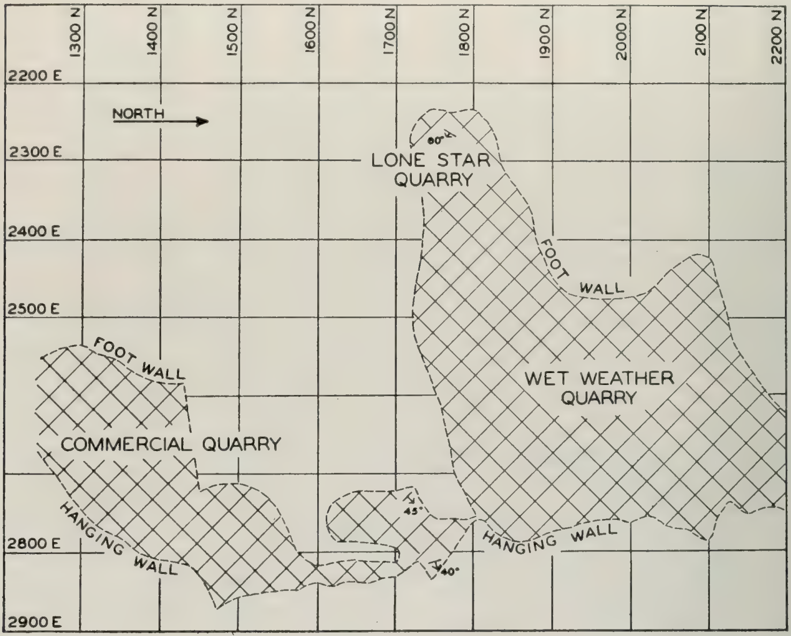
1300 N
1400 N
1500 N
1600 N
1700 N
1800 N
1900 N
2000 N
2100 N
2200 N
2200 E
2300 E
2400 E
2500 E
2800 E
2900 E
NORTH
LONE STAR QUARRY
60°
FOOT WALL
WET WEATHER QUARRY
FOOT WALL
COMMERCIAL QUARRY
45°
40°
HANGING WALL
HANGING WALL

Fig. 3. Sky Blue limestone at 900 feet above sea level. Slightly modified from records of Riverside Cement Company. Map ruled at 100-foot intervals. *Courtesy American Mineralogist.*

The Sky Blue limestone has two facies. One is white like the Chino limestone and locally contains similar yellow predazzite beds. The other facies is sky blue and is found only close to the intrusive quartz monzonite porphyry and its pegmatites, that is, in or near the great masses of contact rock. Masses of blue rock 50 feet thick, especially in the southern part of Wet Weather quarry, were practically pure calcite. Elsewhere patches of the blue limestone the size of a man's hand spot the garnet and idocrase-rich contact rock.

Quartzite and Schist

Above the Chino limestone, and usually separated from it by a quartz diorite sill, there are commonly a few feet of quartzite and quartz-biotite schist. These rocks are similar to those much more extensively developed west of Crestmore in the Jurupa Hills.

A small lens of fine-grained quartz-rich rock, containing some feldspar and brown biotite, in Chino limestone at about 1400 N., 1650 E., (fig. 2) is considered to have been quartzite on the basis of surviving specimens, though apparently mapped by Daly (19, p. 640) as quartz monzonite porphyry.

Perris Quartz Diorite

The country rock about Crestmore and Riverside and extending far to the south to the vicinity of Perris[2] is a fairly uniform quartz-biotite diorite, which locally becomes a granodiorite through the presence of relatively small amounts of orthoclase. The quartz diorite often contains green hornblende in addition to the brown biotite. The Perris quartz diorite is usually gneissoid with streaks of the dark minerals and often numerous small lens-shaped dark inclusions. The gneissoid banding is roughly parallel to the major surfaces of the larger included masses of metamorphosed sediments or dark-colored igneous rocks.

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[2] Dudley, Paul H., Geology of a portion of the Perris block, southern California: California Div. Mines Rept. 31, pp. 487-506, 1936.

Quartz Monzonite Porphyry

Two or three large masses of quartz monzonite porphyry cut the limestones and contact rocks of Sky Blue Hill, and can be seen especially well in the west face of Commercial quarry (fig. 4). A somewhat similar rock was present as smaller bodies in the Chino limestone, especially near its footwall. Apparently the quartz monzonite porphyry and related rocks occurred only in limestone or contact rock.

The porphyry comes into contact with the Perris quartz diorite at the extreme south end of Commercial quarry (fig. 4) but the age relationships are not entirely certain. The porphyry is probably younger than the quartz diorite, as indicated by Daly (19).

The typical quartz monzonite porphyry of Sky Blue Hill is a massive, gray, mottled rock which contains about equal quantities of orthoclase and oligoclase, with abundant quartz and scattered grains and aggregates of pale pyroxene. Phenocrysts of feldspar are commonly 1 or 2 millimeters in diameter and the individual grains of pyroxene somewhat smaller. The feldspars are anhedral and the pyroxene grains are both anhedral and commonly clumped together as irregular aggregates. The groundmass is microcrystalline and made up of anhedral grains. The texture is an unusual one for an igneous rock and suggests secondary changes after its first crystallization or partial crystallization.

In the northern part of Commercial quarry and on the south wall of Wet Weather quarry, the porphyry is more varied in texture and mineral composition, and much of it is quite dark colored. Quartz is rare or absent. A sample collected 30 feet east of station 31 (Wet Weather quarry) is all oligoclase and pyroxene. One from station 9 (Commercial quarry) is mostly alkali feldspar and green hornblende.

The very fine-grained pipes and horses in the Chino limestone were somewhat varied in composition. One, as previously mentioned, is thought to have been merely a quartzitic lens, but the remainder may be grouped with the quartz monzonite porphyry of Sky Blue Hill, following Daly (19). The principal pipe in the Chino limestone was 35 to 40 feet across and dipped about 45° in the direction N. 60° E., from its outcrop at elevation 946 feet, 1275 N., 1660 E. (fig. 2), some 450 feet southeast of the mine shaft. A single thin-section of this rock is largely pyroxene, with smaller percentages of quartz, feldspar, pyrrhotite, etc. This pipe was enveloped in contact rock a few feet thick, largely garnet and locally containing wollastonite.

Mixed Rock

At the north end of Commercial quarry, between locations 6 and 10 (fig. 4) unusual types of quartz monzonite porphyry are intimately mingled with contact rock and pegmatite. Part of the quartz monzonite porphyry of this area contains pale brown garnet, and much of the

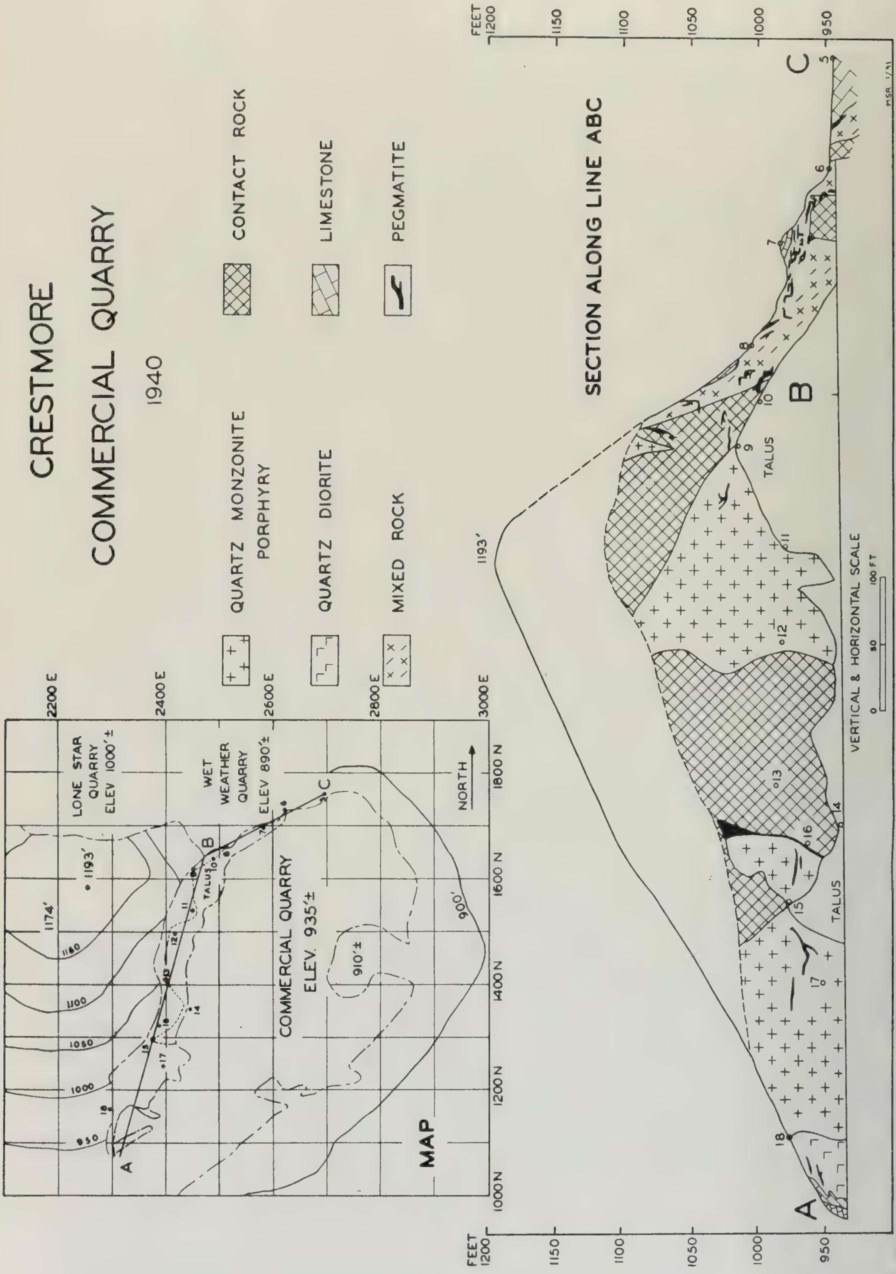
CRESTMORE
COMMERCIAL QUARRY
1940
QUARTZ MONZONITE PORPHYRY
QUARTZ DIORITE
MIXED ROCK
CONTACT ROCK
LIMESTONE
PEGMATITE
MAP
LONE STAR QUARRY ELEV 1000'±
WET WEATHER QUARRY ELEV 890'±
COMMERCIAL QUARRY ELEV. 935'±
910'±
900'
1174'
1193'
1150
1100
1050
1000
950
TALUS
NORTH
2200 E
2400 E
2600 E
2800 E
3000 E
1000 N
1200 N
1400 N
1600 N
1800 N
A
B
C
SECTION ALONG LINE ABC
1193'
TALUS
TALUS
VERTICAL & HORIZONTAL SCALE
0
50
100 FT
FEET
1200
1150
1100
1050
1000
950
MSR 1/41

FIG. 4. Section across Commercial quarry, 1940. Index map ruled at 100-foot intervals. *Courtesy American Mineralogist.*

remainder is of the dark-colored type, lacking quartz, and of variable mineral composition. There is a common absence of the porphyritic texture, and locally an irregular, almost gneissoid banding.

Pegmatite

Quartz Monzonite Porphyry Pegmatites. Pegmatites were found to be abundant in the Commercial quarry by Eakle (4), but very few were recognized by Daly (19) possibly in part because he used the term in a restricted sense. Since the 1938 quarrying, pegmatites are again striking features of the face. They are shown rather diagrammatically in figures 4 and 6. They are more numerous than indicated, especially in the mixed rock. They occur commonly as clean-cut dikes in porphyry and contact rock, rarely extending as much as 2 or 3 feet into pure limestone. They are also present, more rarely, as vaguely bounded irregular areas in the porphyry, especially south of station 16.

The typical pegmatite of the Commercial quarry shows the usual variable grain size, ranging from fine graphic granite up to large individual crystals of feldspar 15 or 20 centimeters across. The graphic texture is relatively rare. The principal minerals, all of which are usually present, are quartz, microcline and oligoclase, or, less commonly, albite. The other constituents are fairly constant in a single dike, but vary considerably from the north to the south end of the Commercial quarry face. At the north end, pale green epidote is present, and locally also axinite, allanite, prehnite, datolite, zoisite (var. thulite), colorless garnet, zircon, and several zeolites. At the south end, the rather large vertical dike near station 16 is characterized by 10 to 40 percent of andradite garnet in crystals 1 or 2 centimeters across. Allanite is fairly abundant in some dikes, in southern Commercial quarry, notably in that containing andradite.

The northern dikes are characterized by cavities into which project crystals of microcline or epidote, or zeolites. Some of the cavities are partially filled with coarse anhedral blue calcite, just like that of the Sky Blue limestone, now obviously in the process of removal by solution. In such cases the calcite may represent the remains of blue limestone inclusions, especially as many inch-long bits and rarer larger masses of blue calcite, or calcite and wollastonite, are also present in the pegmatites. However, some of the blue calcite at Crestmore must be wholly secondary. Blue calcite veinlets 5 millimeters thick have been found in the fine-grained grossularite rock of Lone Star quarry, and Kelley (22) has recorded similar veins in idocrase and diopside contact rock.

Much less common than the pegmatites are veins of pegmatitic aspect, which lack either quartz or feldspar.

Quartz Diorite Pegmatites. Within a few miles of the Crestmore quarries there are many hundreds of pegmatite dikes in or near the quartz diorite. However, the few diorite pegmatites which penetrate the Crestmore limestones, especially in the mine, seem to be of quite simple mineral composition and furnish garnet-rich, relatively uninteresting contact zones only a few feet thick.

Contact Rocks

Normal quartz monzonite porphyry is almost everywhere separated from limestone by 5 to 100 feet of contact rock. The most widespread type is composed primarily of grossularite garnet, with or without grass-green diopside. This rock is prominent on the summit of Sky Blue Hill and makes up a large part of the area of contact rock between stations 12 and 16 (fig. 4). Near station 14 in the southeast part of the latter mass, and elsewhere, the garnet-rich material grades rapidly but irregularly into a rock composed in whole or in part of pale green or brown idocrase. Monticellite accompanies idocrase, and also forms almost pure brown or gray granular masses near limestone, or occurs as gray spots in the limestone. Elsewhere, and especially in the vicinity of residual calcite, very pale yellow-green diopside is present in large cleavable masses or well-formed crystals up to 5 or 10 centimeters in diameter (21). Along the south wall of Lone Star quarry a thin, nearly vertical sheet of fine-grained, spurrite-bearing rock is a prominent element of the narrow contact zone which separates the porphyry, on the south, from the nearly pure limestone to the north. Locally, as in Lone Star quarry or at the extreme southern limit of the Commercial quarry section (quartz diorite contact, fig. 4), masses of coarsely crystalline or fine silky white wollastonite are striking but minor features of the limestone side of contact rock. Numerous other mineral combinations are present and are discussed in more detail in connection with particular quarries or individual minerals.

At many places in the quartz monzonite porphyry contact rock and in the mixed rock, there are dark gray lenses of more or less decomposed biotite schist or gneiss, rarely more than 5 feet thick or 15 feet long. Below station 7 a relatively fresh example is an oligoclase-biotite-hornblende-diopside rock, with perhaps 50 percent oligoclase. The biotite is brown in section, the hornblende green. The mica schist is perhaps the most puzzling part of the contact rock.

CHINO QUARRIES AND MINE

Several quarries, and the underground mine, have been developed in the Chino limestone. The lower quarries have been engulfed in the glory hole above the mine, but the upper Chino quarry (elevation 970 feet) can still be seen, where a flat-lying portion of the limestone has been removed from the upper slopes of Chino Hill. The Chino limestone is white and relatively pure with few accessory minerals other than brucite and graphite, and with contact zones which are only a few feet thick and of relatively monotonous composition. Some excellent dark garnet crystals with numerous faces, including the hexoctahedron, occur along the footwall. Sulphides were abundant in the contact zones surrounding the porphyry pipes and stringers in the Chino limestone. At least one sulphide mass weighing several hundred pounds was found by Mr. R. H. Wightman in the mine; it was made up chiefly of pyrrhotite and sphalerite.

COMMERCIAL QUARRY

As shown in figure 5, Commercial quarry is a bench cut deeply into the east side of Sky Blue Hill. Its floor is about 935 feet above sea level. The photograph (fig. 5) and profile (fig. 4) show the face on the west and northwest sides of this quarry as it was in late 1939 and early 1940. These figures also show approximately the condition which prevailed from 1916 to 1938, during the period of almost complete inactivity in Commercial quarry. In the autumn of 1938 much talus mate-

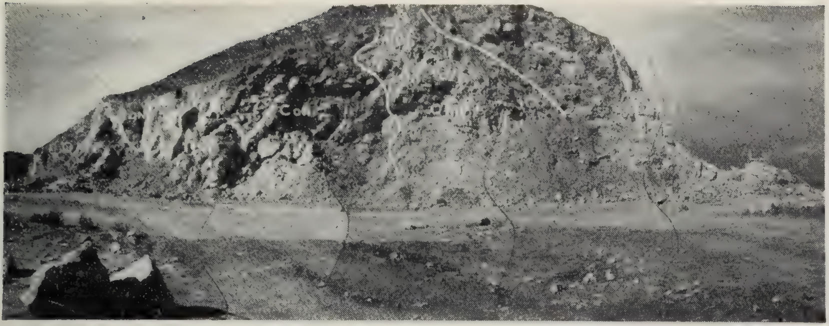

FIG. 5. Composite photograph of Commercial quarry face, February 1940. QMP, quartz monzonite porphyry; Ls, limestone; Con, contact rock. *Courtesy American Mineralogist.*

rial was removed and the lower part of the face was cut back 10 to 50 feet between stations 11 and 14, without making great changes in the types of rock exposed. In 1939 a trench-like cut about 25 feet deep was excavated in the floor, extending west and south about 200 feet from the east edge of the quarry, almost entirely in limestone of varying degrees of purity. This new excavation may be called the 910-foot level of the Commercial quarry.

The Commercial quarry profile (fig. 4) does not show the 910-foot level, but does begin just to the north of it where banded limestone and other rocks are exposed in the slope which extends down from the edge of Commercial quarry to the deeper Wet Weather quarry. The banding, especially where due to brucite nodules in calcite, is considered to represent original bedding, even though other types of banding, especially on the 910-foot level, are in planes almost at right angles to each other and may be due to replacement along joints. The brucite banding roughly parallels the boundaries of the limestone lens, where these are known.

The banded limestone of stations 5 and 7 is underlain by a complex of contact rock, pegmatite, and abnormal monzonite porphyry. Some details of this mixed rock will be described in connection with a more detailed profile of the south wall of Wet Weather quarry. Another exposure of mixed rock occurs at and near the edge of the normal quartz monzonite porphyry, south of station 9, Commercial quarry (fig. 4). Numerous inclusions of garnet rock make a vaguely bounded band in the porphyry 10 to 15 feet from the contact at 9.

The following notes concern the main part of the face (AB on map and profile), and supplement the descriptions under the headings "General Geology of Crestmore" and "Notes on Individual Minerals and Mineral Groups."

The pegmatite shown near station 10 is notable for its large epidote crystals projecting into cavities. Apparently this is the "coarse grained" rock mentioned by Kelley (22). The pegmatites near the top of the cliff above station 9 contained thin but extensive vugs lined with stout prismatic microcline crystals up to 15 centimeters across. Microcline crystals of similar size and habit, showing Carlsbad twinning, were present in the pegmatites of the mixed rock below station 7, but there they were enclosed in clear massive quartz. The pegmatites between 7 and 9 have been the sources of specimens showing (1) thin blades of purple axinite, (2)

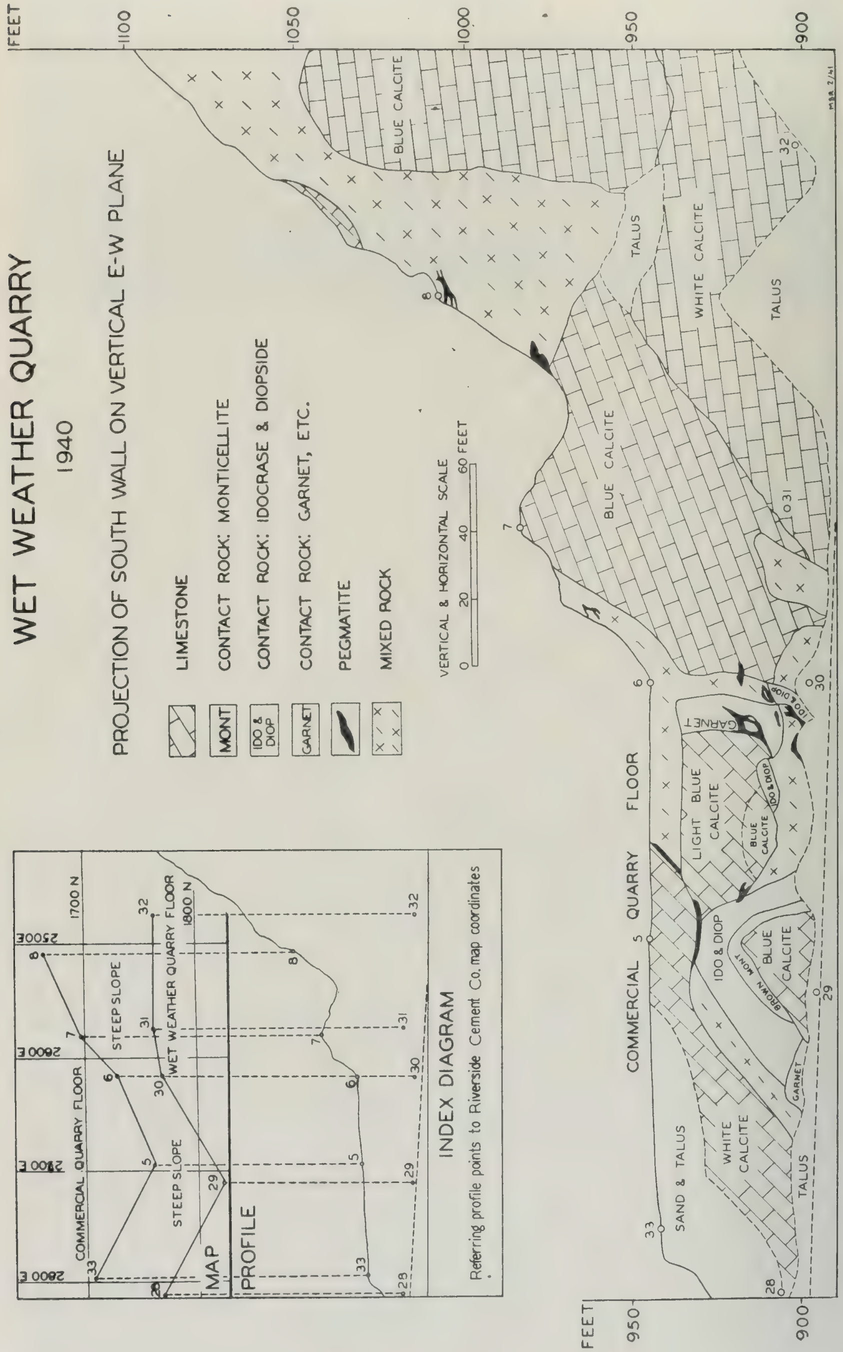
WET WEATHER QUARRY
1940
PROJECTION OF SOUTH WALL ON VERTICAL E-W PLANE
LIMESTONE
MONT CONTACT ROCK: MONTICELLITE
IDO & DIOP CONTACT ROCK: IDOCRASE & DIOPSIDE
GARNET CONTACT ROCK: GARNET, ETC.
PEGMATITE
MIXED ROCK
VERTICAL & HORIZONTAL SCALE
0 20 40 60 FEET
FEET
1100
1050
1000
950
900
BLUE CALCITE
WHITE CALCITE
TALUS
LIGHT BLUE CALCITE
IDO & DIOP
GARNET
BROWN MONT
SAND & TALUS
COMMERCIAL QUARRY FLOOR
28
29
30
31
32
33
5
6
7
8
INDEX DIAGRAM
Referring profile points to Riverside Cement Co. map coordinates
MAP
PROFILE
COMMERCIAL QUARRY FLOOR
STEEP SLOPE
WET WEATHER QUARRY FLOOR
2500E
2600E
2700E
2800E
1700 N
1800 N
MBA 2/41

FIG. 5. South wall of Wet Weather quarry, 1940. *Courtesy American Mineralogist.*

pink thulite with oligoclase and microcline, (3) pale green datolite and green and pinkish prehnite, (4) zeolites both massive and in druses, and (5) fine clear apophyllite in cavities,—all in addition to the epidote mentioned above and a number of other minerals, as indicated elsewhere in this paper.

At the southern edge of the largest mass of garnet contact rock, near station 14, there are large masses of pale green idocrase which are called ''californite'' by collectors. Formerly, east of the present face, pale green pyramidal crystals of idocrase, one or two centimeters across, were thickly distributed through brownish contact rock composed chiefly of monticellite and custerite. Similar material now falls from the cliff above station 9.

Station 15 marks the bottom of a V-shaped downward extension of the summit garnet rock. The coarse-grained, bluish-gray calcite veins in the garnet contain numerous long prisms of scapolite. Secondary radial phillipsite and a little translucent stilbite are also found here, and opalization is extensive.

At and above station 16 there is a notable pegmatite. It is composed chiefly of microcline, oligoclase, quartz, and dark brown andradite garnet, with chloritized pyroxene locally abundant. Allanite (treanorite) and Mineral L (a calcium-thorium silicate) are found chiefly in this pegmatite.

At ''A'', which marks the south end of the quarry face, the contact zone between limestone and quartz diorite is mostly garnet and wollastonite, and only a few feet thick, emphasizing the exceptional nature of the thick contact zones usually present alongside the quartz monzonite porphyry.

WET WEATHER AND LONE STAR QUARRIES

The deepening and extension of Wet Weather quarry in 1941, 1942, and 1943 has undercut and almost wholly destroyed the two previously existing levels in Lone Star quarry, though some remnants of the main or 1000-foot level still exist.

Exceptionally clear intrusive relationships, and the only example of the sharp segregation of the contact minerals into distinctive zones, are to be seen on the south wall of Wet Weather Quarry, shown in figure 6. This section includes most of the BC portion of figure 4, seen from the other side. The central portion of the Wet Weather profile is shown in the photograph of the quarry, figure 7.

At the left side of figure 6, the bedding in the limestone is indicated both by jointing and by brucite-rich streaks 1 centimeter thick and spaced at intervals of 3 to 5 centimeters. The thickness of clearly bedded limestone is only 20 feet. The bedded limestone is underlain by a few feet of banded mixed rock. Underneath the banded rock is a complex of garnet rock cut by quartz monzonite porphyry stringers and succeeded by idocrase-diopside rock which apparently has developed down the dip of the bedded blue limestone below station 5, Commercial quarry.

Above station 29 a small mass of pure blue limestone is backed by and apparently almost surrounded by brown monticellite rock. A 4-inch layer of limestone adjacent to the monticellite is thickly studded with wollastonite and crestmoreite, cut by veinlets which may be altered thaumasite.

An idocrase-diopside zone follows the monticellite, between stations 29 and 30. This zone also contains monticellite, spurrite, and other minerals. It includes some quartz monzonite porphyry streaks, especially along its southwestern margin.

The limestone above 30 contains good crystals of idocrase and diopside, and rarely monticellite in prisms up to 8 centimeters across, as well as large, 1- to 3-centimeter pseudomorphs of crestmoreite after wilkeite. Above station 30, pegmatite lenses and stringers are numerous. One lens in garnet rock is 12 to 18 inches thick and made up of medium- to coarse-grained microcline, oligoclase, and andradite. It is shown very diagrammatically, partly because of dislocations due to blasting. A second lens cuts 2 feet into pure limestone; beyond its nose on the limestone cliff scattered crystals of green idocrase (?) seem to represent an extension of the pegmatitic influence. A nearby compound wollastonite pegmatite veinlet between blue limestone and idocrase-diopside rock is composed of two layers. On the idocrase-diopside side there is fine-bladed wollastonite crystallized perpendicular to the walls. On the blue calcite side there are closely packed microcline crystals, without quartz, embedded in wollastonite and spotted with dark green pyroxene crystals. Some of the microcline crystals are shot through with wollastonite blades. The series of pegmatites along the limestone contact between stations 30 and 7 is one of the most persistent zones of this rock now exposed in the quarries. Many of the higher dikelets are not shown in figure 6.

West of location 30 the profile is simpler. Limestone remnants of the large mass excavated in the making of Wet Weather quarry remain

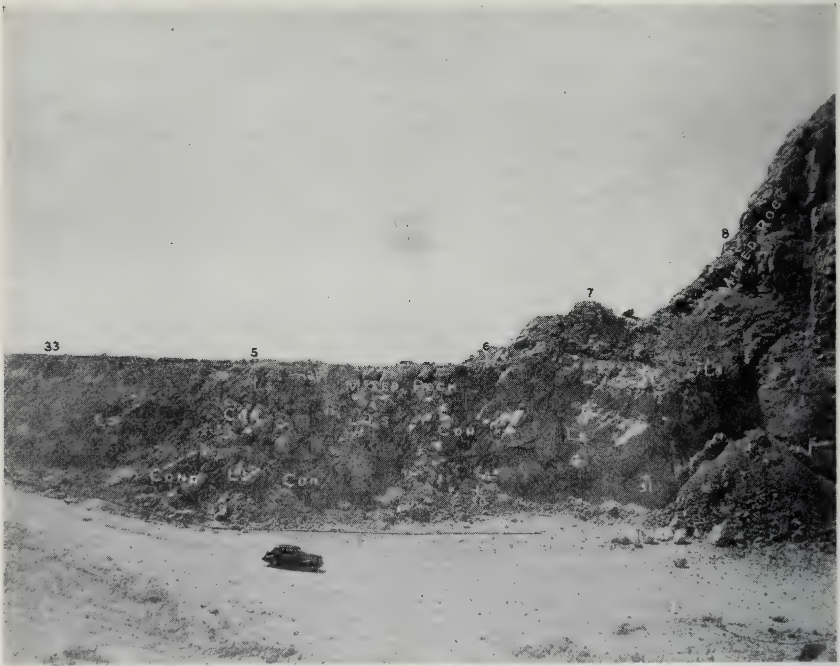

Fig. 7. South wall of Wet Weather quarry, September 1940. Ls, limestone; Con, contact rock. Location numbers same as in figure 6. *Courtesy American Mineralogist.*

still adhering to the silicate wall. Garnet-rich contact rock makes a layer only a very few feet thick between blue limestone and mixed rock which to the west becomes more and more predominantly a quartz monzonite porphyry. The most exceptional feature is the development of abundant black prisms of Mineral B (ludwigite?) in the vein-like margin of the limestone body at location 31. Many blocks which fell from the wall at the right of station 8, figure 7, were rich in pink wilkeite and white crestmoreite, associated with idocrase, calcite, etc.

As shown in figure 2, Wet Weather and Lone Star quarries have now coalesced, and there is only a narrow ridge between Commercial quarry and the former Lone Star. In the map of figure 3 an earlier, approximately 1939, condition is shown.

At present the south wall of the old Lone Star quarry presents a huge face of limestone, topped by contact rock with adhering patches of blue calcite, and with quartz monzonite porphyry showing through where quarrying has removed both limestone and contact rock. The face is very steep (up to 80°), rising over 100 feet above the remnants of the Lone Star floor and continuing down to the floor of the Wet Weather quarry more than 100 feet lower.

Quartz Diorite Contact Rock. At the west side of the Lone Star portion of the quarry the enveloping quartz diorite is exposed, its contact with the overlying limestone striking N. 52° E., dipping 45° SE. The limestone in contact with the quartz diorite is white with a fairly uniform development of red garnet and wollastonite contact rock about a foot thick. Epidote and quartz occur in small pegmatites projecting slightly into the calcite. Brucite is the commonest accessory mineral in the mass of limestone, in bands roughly parallel to the quartz diorite contact. Chondrodite (?) in dark green grains and 1-millimeter crystals was found in very rare and limited occurrences near the contact; phlogopite in red-brown flakes and 5-millimeter crystals rarely; magnetite as 1-millimeter octahedrons in predazzite rarely; arsenopyrite, pyrite, and pyrrhotite rare, near the contact; graphite rare; hydrotroilite rather abundant. The contact between the quartz monzonite porphyry and the quartz diorite can not be seen here as yet.

Quartz Monzonite Porphyry Contact Rock. The layer of blue calcite and contact rock on the face of the quartz monzonite porphyry is here only 15 to 20 feet thick, and the change from blue to white limestone probably cuts across the banding (bedding?) of the brucite limestone, though the progress of quarrying was not observed continuously by the author and so he can not be entirely certain on this point. The principal contact minerals here are massive garnet, wollastonite, diopside, idocrase, monticellite, and spurrite. Metamorphic zones near the quartz monzonite porphyry contact can not be well ascertained, but the presence of large blocks of dark gray-green spurrite-bearing rock in the talus all along the face is notable. This rather fine-grained, massive rock also contains merwinite, gehlenite, and monticellite, though not all are present in every sample. The largest block of spurrite rock found on the quarry floor was over 4 feet thick, least dimension, with veins and surfaces of silky, soft white thaumasite up to 5 centimeters thick. Under the lens the thaumasite is seen to occur as closely grouped, radiating, acicular, hexagonal crystals with flat basal terminations.

Table 1. Minerals of Crestmore

Number	Mineral	Composition	Occurrence: Quarry or station (in Community and Wet Weather quarries)	Occurrence: Quartz diorite	Occurrence: Quartz monzonite porphyry	Occurrence: Quartz monzonite porphyry pegmatite	Occurrence: Limestone, including predazzite	Occurrence: Contact rocks	Occurrence: Mixed rock	Occurrence: Secondary veins; weathering products	Occurrence: Miscellaneous and uncertain	Remarks Legend: A: Accessory mineral C: Common F: Frequent G: of General distribution M: Constituent mineral R: Rare G>C>F>R WW: Wet Weather quarry Ch: Chino quarry LS: Lone Star quarry Mi: from the mine 910...: 910-ft. level, Commercial quarry
1	Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	7, 18							R		Felted layers on joints in contact rocks
2	Albite	$NaAlSi_3O_8$		M		M						
3	Allanite(?)	$(Ca,Ce,La)_2(Al,Fe''',Fe'')_3Si_3O_{12}(OH)$	6, 9, 17, 18,Mi, LS			C						"Treanorite"
4	Andradite garnet	$Ca_3Fe_2Si_3O_{12}$	16			C			F			Dark brown crystals of pegmatites
5	Andesine	Ab, 70-50%; An, 30-50%										Vide Daly (19)
6	Anglesite	$PbSO_4$										Vide Eakle (4)
7	Apatite	$Ca_5(F,Cl,OH)(PO_4)_3$	14-16	A			R	R				
8	Apophyllite	$4CaSi_2O_5.KF.8H_2O$	7 LS			R		R		R		Also silica pseudomorphs
9	Aragonite	$CaCO_3$	LS 910							F		Rosettes
10	Arsenopyrite	FeAsS	12-14 Mi, WW				R					
11	Augite	$CaMgSi_2O_6$ with $(Mg,Fe)(Al,Fe)_2SiO_6$	15		M?			F	F			Vide Daly (19)
12	Axinite	$H(Fe,Mn)Ca_2Al_2BSi_4O_{16}$	8-10			R		R	R			Seams; thin purplish crystals
13	Azurite	$Cu_3(OH)_2(CO_3)_2$	Mi, etc.				R	R				
14	Biotite	$K_2(Mg,Fe)_6(Si,Al)_8O_{20}(OH)_4$	18	M			M	M				Rock mineral
15	Bornite	Cu_5FeS_4	Mi, etc.				R	R			R	
16	Brucite	$Mg(OH)_2$	Ch, LS, WW910				C					White or yellow grains
17	Bytownite-anorthite	Approx. 10% Ab; 90% An			R						R	Vide Daly (19)
18	Calcite	$CaCO_3$	G		F	F	M	M	F	F	F	
19	Centrallasite	$4CaO.7SiO_2.5H_2O$				R						Vide Foshag (11)
20	Cerussite	$PbCO_3$	10			R				R		Alteration of galena
21	Chalcedony	SiO_2	9							R		
22	Chalcocite	Cu_2S			R			R			R	
23	Chalcopyrite	$CuFeS_2$	14 WW					R				Crystals and masses in garnet-calcite contact rock

24	Chondrodite (?)	$Mg_5F_2Si_2O_8$	910, WW				C					Perhaps clinohumite
25	Chrysocolla	CuO, SiO_2, H_2O	9							R		
26	Chrysotile	$H_4Mg_3Si_2O_9$	15					R				
27	Chlorite	$(Mg,Fe)_5Al(AlSi_3O_{10})(OH)_8$	29					R				
28	Clinochlore	$H_4Mg_3Si_2O_9.H_4Mg_2Al_2SiO_9$	LS, etc.					R				
29	Clinozoisite	$HCa_2Al_3Si_3O_{13}$	12, LS			R						Pale, striated, crystals
30	Crestmoreite	$4CaSiO_3.7H_2O$	LS				C	C				Pseudomorphs after wilkeite
31	Cuprite	Cu_2O	14, LS					R				Alteration of chalcopyrite
32	Custerite	$[Ca(F,OH)]_2SiO_3$						R				
33	Danburite	$CaB_2(SiO_4)_2$									R	M. Vonsen's collection, Petaluma, Calif.
34	Datolite	$CaBOHSiO_4$	8			R						
35	Deweylite	$4MgO.3SiO_2.6H_2O$										Vide Daly (19)
36	Diallage	Close to augite				C						
37	Diopside	$CaMgSi_2O_6$	G		M?		R	C	C			
38	Dolomite	$CaMgC_2O_6$	Mi							R		
39	Ellestadite	$Ca_{10}Si_3S_3O_{24}(OH)_2$	WW?					R				See McConnell (24)
40	Epidote	$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	10, etc.			C	R	F				Striated crystals; massive
	Foshagite											See Hillebrandite
41	Galena	PbS	10, etc.			R	R	F				
42	Gehlenite	$Ca_2Al_2SiO_7$	LS, WW, 4-5, 13-14					R				With spurrite; with plazolite (?)
43	Graphite	C	WW, Ch				C					Abundant in Chino limestone
44	Greenockite; var. xanthochroite	CdS								R		Vide Eakle (4)
45	Grossularite garnet	$Ca_3Al_2Si_3O_{12}$	G				C	C	C			
46	Gypsum (selenite)	$CaSO_4.2H_2O$	LS							R		With sphalerite
47	Hornblende	$HCaMgFeAl$ silicate	15	M	R							
48	Hematite	Fe_2O_3	LS, 13-15					R		R		Alteration of chalcopyrite, etc.
49	Hillebrandite; var., foshagite	$H_2Ca_5(SiO_4)_3.2H_2O$	14-17, WW					R		R		Veins in idocrase
50	Hydromagnesite	$3MgCO_3.Mg(OH)_2.3H_2O$	WW, Ch				F			F		Alteration of brucite
51	Hydrotroilite	$FeS.nH_2O$	WW, LS				R					
52	Hypersthene	$(Mg,Fe)SiO_3$										Vide Daly (19). Not at quarries
53	Idocrase	$Ca_{10}Al_4(SiO_4)_5.2Mg(OH,F)_2$	G				C	C	C			
54	Jurupaite	$H_2(Ca,Mg)_2Si_2O_7$	Com							R		Vide Eakle (9)
55	Kaolinite (?)	$Al_2Si_2O_5(OH)_4$	28							R		
56	Labradorite	50-30%, Ab; 50-70%, An										Rock mineral (Eakle, 4; Daly, 19)
57	Laumontite	$(Ca,Na_2)Al_2Si_4O_{12}.4H_2O$	9-11			C						Abundant in pegmatites
58	Lollingite	$FeAs_2$	Mi									Vide Kelley (22)
59	Limonite	$Fe_2O_3.nH_2O$	WW, LS, 17							C		In contact rock, pseudomorphs after pyrite
60	Ludwigite (?)	$3MgO.B_2O_3.FeO.Fe_2O_3$	WW, LS				R					=Mineral *B*
61	Magnesite (?)	$MgCO_3$	910							R		Dense white veinlets; indices low, some water
62	Magnetite	$(Fe,Mg)Fe_2O_4$	WW, 10-11	A	A		R	R				1 mm. crystals in predazzite
63	Malachite	$Cu_2(OH)_2CO_3$	9-11							R		In garnet rock

Table 1. Minerals of Crestmore—Continued

Mineral		Composition	Occurrence									Remarks
Number			Quarry or station (in Community and Wet Weather quarries)	Quartz diorite	Quartz monzonite porphyry	Quartz monzonite porphyry pegmatite	Limestone, including predazzite	Contact rocks	Mixed rock	Secondary veins; weathering products	Miscellaneous and uncertain	Legend: A: Accessory mineral C: Common F: Frequent G: of General distribution M: Constituent mineral R: Rare G>C>F>R WW: Wet Weather quarry Ch: Chino quarry LS: Lone Star quarry Mi: from the mine 910...: 910-ft. level, Commercial quarry
64	Manganite (?)	$Mn_2O_3.H_2O$	14			R		R				
65	Merwinite	$Ca_3Mg(SiO_4)_2$	WW, 13					F				With spurrite; fine grained
66	Microcline	$KAlSi_3O_8$	8–15			M						
67	Molybdenite	MoS_2	Mi,LS						R		R	From mine, with garnet rock
68	Monticellite	$CaMgSiO_4$	8–14, WW, LS, 910				C	C				Usually brown or pink or glassy gray
69	Montmorillonite	$(Mg,Ca)O.Al_2O_3.5SiO_2.nH_2O$	Mi							R		With prehnite, from the mine
70	Muscovite	$KAl_2(Si_3Al)O_{10}(OH)_2$									C	In schist and quartzite
71	Nontronite	$H_4Fe_2Si_2O_9$	15, etc.							C		
72	Okenite	$H_2CaSi_2O_6.H_2O$						R				Vide Eakle (4)
73	Oligolase	90-70%, Ab; 10-30%, An	8-15, etc.	M	M	M						
74	Opal (common)	$SiO_2.nH_2O$	G							C		
	(hyalite)		G							F		
75	Orthoclase	$KAlSi_3O_8$	G	M	M							
76	Pargasite (?)	$NaCa_2(Mg,Fe)_5AlSi_7O_{22}(OH)_2$	LS					R				Large crystals
77	Periclase	MgO					R					From mine, etc. Cores in brucite
78	Phillipsite	$(K_2,Ca)Al_2Si_4O_{12}.4\frac{1}{2}H_2O$	15					R				
79	Phlogopite	$K_2Mg_6(Si_6Al_2)O_{20}(OH)_4$	7-8,29,30 Ch, LS					F				
80	Plazolite	$3CaO.Al_2O_3.2SiO_2.2H_2O$	14					R				Crystals; (?) massive, with gehlenite
81	Prehnite	$H_2Ca_2Al_2Si_3O_{12}$	8-9, etc.			C						
82	Pyrite	FeS_2		A	A	A		R				
83	Pyrrhotite	FeS	WW, Ch				R	C				Small crystals; large masses
84	Quartz	SiO_2	G	M	M	M		C				
85	Realgar	AsS	14					R				In brown monticellite
86	Riversideite	$2CaSiO_3.H_2O$	14					C				Veinlets in idocrase. ?=crestmoreite
87	Rutile	TiO_2	WW					R			R	
88	Scapolite	$CaCO_3.3CaAl_2Si_2O_8+NaCl.3Na\ AlSi_3O_8$	15, WW					R				White crystals in calcite veins in garnet; etc.

89	Sepiolite	$H_4Mg_2Si_3O_{10}$	LS					R			R	
90	Sericite	$(H,K)AlSiO_4$								R	R	Especially in seams
91	Serpentine	$H_4Mg_3Si_2O_9$	910				R	R				
92	Sphalerite	$(Zn,Fe)S$	WW, Ch			R		R	R			
93	Sphene	$CaTiOSiO_4$	15, etc.	A	A	A			R			
94	Spinel	$(Mg,Fe,Mn)(Al,Cr)_2O_4$	13-14, 910					R				Blue grains and crystals in pale green grossularite
95	Spurrite	$2Ca_2SiO_4.CaCO_3$	29, LS, 4-5,13-14					C				
96	Stibnite	Sb_2S_3	WW					R				
97	Stilbite	$CaAl_2Si_2O_6.6H_2O$	15			R		R				With scapolite and phillipsite in calcite veins in garnet
98	Strontianite	$(Sr,Ca)CO_3$	LS									
99	Talc?	$H_2Mg_3Si_4O_{12}$	WW					R				With brown tourmaline
100	Tetrahedrite	$Cu_{10}Zn_2Sb_4S_{13}$										Vide Eakle (4)
101	Thaumasite	$CaSiO_3.CaCO_3.CaSO_4.15H_2O$	LS, WW 910, 16							C		Veins and joints in spurrite rock
	Thulite											See Zoisite
102	Tilleyite	$CaCO_3.Ca_2SiO_4$						R				Vide Larsen and Dunham (16)
103	Tourmaline, Brown	$H_4NaMg_3B_3Al_6Si_6O_{31}$	WW					R				
104	Tourmaline; var. schorl	$H_4NaFe_3B_3Al_6Si_6O_{31}$	10–18			R						More abundant in quartz diorite pegmatites
	Treanorite											See allanite
105	Tremolite (?)	$Ca_2Mg_5Si_8O_{22}(OH)_2$	18									
106	Uralite	(Hornblende)								R		Vide Daly (19)
107	Vermiculite	Hydrated biotite	18	R						R		In quartz diorite pegmatites
108	Wilkeite	$3Ca_3(PO_4)_2.CaCO_3.3Ca_3[(SiO_4)(SO_4)].CaO$	910, 8, 14, 29				F	R				Also from SE wall of Lone Star quarry
109	Wollastonite	$Ca_3(SiO_3)_3$	G			R	F	C				Fine crystals; silky masses
110	Xanthophyllite	$H_8(Mg,Ca)_{14}Al_{16}Si_5O_{52}$	910, 13-16, LS				F	F				Usually in idocrase or calcite
111	Zircon	$ZrSiO_4$	8–15	A	A	R						Dark brown crystals up to 5 mm. long
112	Zoisite; var. thulite	$Ca_2Al_3Si_3O_{12}(OH)$	8–10			R						Pink crystals up to 15 mm. long
	Mineral B		WW, LS				R					Fine crystals up to 15 mm. long. Ludwigite (?)
	Mineral C		LS							R		White, radiating, on altered wollastonite
	Mineral D		LS							R		White, radiating CaMg silicate in peg.-like vein cutting idocrase
	Mineral F		14, etc.							F		Blue films of CuCaAl Si-carbonate on joint cracks in garnet rock
	Mineral G		910					R				Brown pseudomorphs; MgAl silicate
	(Mineral H)											Discussion on a later page
	Mineral J		910					R				A white, silky radial CaAl silicate with Mineral *G*
	Mineral K		910							F		White, chalky prisms of CaAl silico-carbonate on Mineral *P*
	Mineral L		15			R						White, soft ThCa silicate in andradite-feldspar-treanorite peg.
	Mineral M		15			R						An isotropic substance with Mineral *L*
	Mineral N		LS							C		Thin yellow films of PbCuCa vanadate on joint surfaces
	(Mineral O)											See Humite Group
	Mineral P		910							R		Colorless, triclinic crystals of CaAlMg fluosilicate in seams in spurrite-calcite rock
	Mineral Q		WW							R		Soft white fibers of Ca silicate on loose limestone blocks

Large blocks of pegmatite which have been blasted from the east end of the Lone Star face, are mostly very similar to those which have fallen into Commercial quarry from the opposite side of the same ridge. Exceptionally the pegmatitic masses contain blue calcite and wollastonite with cleavage surfaces 4 or 5 centimeters across, and clear, colorless apophyllite with cleavage surfaces up to 15 millimeters across.

NOTES ON INDIVIDUAL MINERALS AND MINERAL GROUPS

Station numbers refer to localities in Commercial quarry (stations 5-18; cf. fig. 4) and Wet Weather quarry (stations 28-32; cf. fig. 6).

Actinolite. See under Amphiboles.

Allanite. See Epidote Group.

Amphibole Group: Hornblende, pargasite (?), actinolite, tremolite. Greenish-black hornblende is a constituent of the quartz diorite, and of the mica schist lenses in the contact rock. Actinolite and tremolite are rare, and found only in veins or clefts. In 1941 and 1942 large crystals of dark green pargasite (?) were found in Lone Star quarry.

Actinolite was found near stations 7 and 18. At the former locality coarsely fibrous, silky masses of the pure mineral up to 8 centimeters in length and 5 millimeters in thickness occur in a coarse quartz-calcite-epidote vein of pegmatitic aspect. At station 18 blade-like actinolite crystals averaging 5 by 30 millimeters are distributed sparsely through an altered pegmatite which cuts the quartz diorite and probably is genetically related to that rock. *Tremolite* (?) asbestus is extremely rare on joint surfaces at the same locality.

After the publication of the 1941 report (28), Richard Strehle found dark green, almost black, *pargasite* (?) crystals up to 6½ centimeters in length associated with dark green mica (phlogopite?), idocrase, and pyrrhotite in limestone at the east edge of Lone Star quarry, near 1800 N., 2200 E. A preliminary analysis by J. D. Laudermilk indicates a calcium-magnesium-aluminum-iron silicate, but silica is low for an amphibole. The crystal habit is very short prismatic, and there is some variation in the forms present. The most perfect crystal found is terminated by large clinodome faces, probably (041); faces in the prism zone are vertically striated, (100), (110), and a probable (140) being the most prominent forms. Cleavage (110), fairly good; also other cleavages or partings; $\beta = 74°$; $110 \wedge 1\bar{1}0$ 56°. Optically positive, nearly neutral. $\alpha = 1.643 \pm .002$, $\gamma = .1665 \pm .003$. $Z \wedge \check{c}$ 28° or 29°. On cleavages various extinction angles, most 23° or less, but not rarely 31°. Very pale in section with slight pleochroism: X = palest yellow, Y = nearly colorless, and Z = pale bluish green.

No pale amphibole has been found in the limestones or contact rocks. Elsewhere in southern California tremolite is abundant in similar limestones.[3] The absence of tremolite from the Crestmore metamorphic zones probably indicates fairly high temperatures at the time of their formation,[4] though an element of uncertainty is introduced by the presence of contaminating and presumably hydrous pegmatitic intrusives.

Andradite. See under Garnet.

Apatite. Rare, between stations 14 and 16, as pale green, clouded, prismatic crystals 2 to 5 centimeters in length, with rounded terminations. Mineral associates are coarsely crystalline blue calcite, idocrase, grossularite, and diopside. Minute blue apatite crystals of the type mentioned by Eakle (4) now can be found only on the old Commercial quarry dump.

Apophyllite. Fine, clear, fresh, short pyramidal crystals. Especially from Lone Star quarry, in cavities in limestone (or calcite pegmatite). Also, in Lone Star quarry and on the Commercial 910-foot level, completely altered to silica pseudomorphs which preserve the birefringence and interference figure of apophyllite. These pseudomorphs have been studied by E. H. Bailey.[5]

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[3] Woodford, A. O., and Harriss, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, California: California Univ., Dept. Geol. Sci., Bull. 17, pp. 265-304, 1928.

[4] Bowen, N. L., Progressive metamorphism of siliceous limestone and dolomite: Jour. Geology, vol. 48, pp. 225-274, 1940.

[5] Bailey, E. H., Skeletonized apophyllite from Crestmore and Riverside, California: Am. Mineralogist, vol. 26, pp. 565-567, 1941.

Aragonite. Of rather general occurrence in crusts and veinlets, but found notably in two localities: (1) in the Lone Star quarry, as acicular crystals in gleaming stellate groups up to 15 millimeters in diameter, lining small veinlets or cavities in limestone; (2) on the 910-foot level of the Commercial quarry, as similar rosettes of transparent crystals averaging 1 by 7 millimeters in size, and showing *b*, *k*, and *m* faces. Occurrences of the crust-like type of aragonite have been noted especially near stations 12 and 14 of the Commercial quarry.

Brucite. Waxy yellow or gray or pale brown grains 1 to 5 millimeters across, thickly scattered through certain zones in the limestone, making the rock called predazzite. Some grains are recognizable as stepped and distorted octahedrons, and rarely such grains from an active quarry or from the mine have been found to contain minute bits of periclase. Therefore, these brucite grains are considered to have formed by the hydration of periclase. At surface outcrops the brucites have been leached away and are represented by rusty cavities. The predazzite layers, commonly 1 or 2 or 3 feet thick, are roughly parallel to the boundaries of the limestone lenses and hence are thought to represent beds of metamorphosed dolomitic limestone (not pure dolomite, as the chemical analyses rarely if ever show enough MgO). Predazzite is more abundant in the Chino than in the Sky Blue limestone. R. H. Wightman states that in both limestones, and also in other southern California examples, brucite is most abundant near the footwall.

A few masses of pure gray brucite several inches across were found by Mr. Wightman in the mine, on the limestone footwall adjacent to the garnet zone which envelopes a stringer from the porphyry pipe mentioned under the heading "Quartz Monzonite Porphyry."

Chlorite. Found as thin, blue-green 1 by 1 millimeter plates in blue calcite above station 29, Wet Weather quarry, with grossularite and wilkeite in blue limestone. Also very pale green clinochlore or prochlorite in Lone Star quarry, as groups of 5- to 10-millimeter flakes forming the matrix of pale diopside crystals; biaxial, +, 2V 5°–10°, $\beta = \alpha = 1.582 \pm .002$. $\gamma - \alpha = .010 \pm$.

The most striking and exceptional chlorite is colorless and transparent, like isinglass, occurring sparingly as flexible plates 6 to 8 centimeters across, associated with monticellite-idocrase rock near station 16. A slightly ferruginous magnesium-aluminum silicate; +, 2V practically 0°, $\alpha = \beta = 1.577 \pm .002$, $\gamma = 1.582 \pm .003$.

Chondrodite. See Humite Group.

Clinozoisite. See Epidote Group.

Crestmoreite. The soft, white, silky, hydrous calcium silicate minerals at Crestmore are not easily distinguished. Their optical properties are variable. Perhaps all should be called crestmoreite; perhaps riversideite (Eakle, 4) and even a third mineral should be recognized.

Cuprite (ferruginous). Found sparingly near station 14, both massive and as pseudomorphs of chalcopyrite measuring up to 1 by 2 centimeters in size, in a garnet-calcite contact zone. Identification somewhat doubtful.

Diopside. See Pyroxenes.

Dolomite. Found in 1942 by R. H. Wightman and M. P. Yackel. A few thin, fine-grained, almost porcellaneous veins in the limestone of the mine. Proved by chemical analysis in the laboratory of the Riverside Cement Company. Only this rare secondary vein-dolomite has been found at Crestmore. Apparently all original dolomite disappeared during metamorphism. Elsewhere in the region crystalline limestone with tremolite is associated with dolomite, but predazzite is lacking.[6]

Epidote Group: Epidote, clinozoisite, thulite, and allanite (treanorite). Widespread in pegmatites; epidote also in contact rock.

Ordinary yellow-green or dark green *epidote* is locally abundant, either as well-formed or partially formed crystals in pegmatitic cavities, as at station 10, or as rounded crystals in limestone, near pegmatite or plutonic contacts, e.g. near the quartz diorite at the northwest side of Lone Star quarry.

Clinozoisite. Found sparingly near station 12, in well-developed, pale brownish-green crystals, slightly striated parallel to elongation (*b*), and measuring up to 15 millimeters in length. The crystals occurred as divergent groups in a feldspathic pegmatite cutting garnet rock. This clinozoisite is practically neutral with strong dispersion of the optic axes, and shows anomalous blue and yellow interference colors. Indices vary slightly about the following values: $\alpha = 1.713$, $\beta = 1.718$, $\gamma = 1.723$.

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[6] Woodford, A. O., and Harriss, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, California: California Univ., Dept. Geol. Sci., Bull. 17, pp. 265-304, 1928.

Zoisite, var. *Thulite.* Bright pink crystals in pegmatites high on the face above stations 8 and 10. Practically colorless under the microscope. Apparently pigmented by a little iron and still less manganese. Indices low: e.g. $\alpha = 1.688 \pm .003$, $\gamma = 1.698 \pm .003$. Positive; 2V variable, ranging upward from about 60°. Intergrowths with and perhaps gradations to gray clinozoisite; the intergrowths in microscopic bands which resemble polysynthetic twin laminae.

Allanite. Fairly common in the pegmatites associated with the quartz monzonite porphyry, mostly in the southern part of Commercial quarry and especially in the big andradite pegmatite alongside station 16. Most of the allanite specimens were called "treanorite" by Woodford, Crippen, and Garner (28), but further study of the evidence has convinced the author that treanorite must be considered a synonym of allanite, at least for the present.

Allanite (treanorite) is almost always in fresh, black or gray, tabular crystals 1 to 25 millimeters across and $\frac{1}{4}$ to 5 millimeters thick. A few examples, and especially some of the best very small crystals, are prismatic, elongated parallel to the *b* crystallographic axis. Slight alteration is often apparent in microscopic preparations, and one large tabular crystal has been found which is completely altered.

The crystals are usually tabular parallel to (100). Many, perhaps the majority, are two-fold (rarely three-fold) twins with composition plane parallel to the large (100) faces. Other forms than (100) are represented chiefly by narrow dome and prism faces. Most cross-sections are narrow, parallel-sided, and bluntly terminated, as would be expected from the tabular habit, but some cross-sections are rhombic indicating a rather different habit. Re-entrant angles due to twinning are common but not prevalent, the twinning being most commonly indicated by the rather poor cleavages. The principal cleavage is probably basal.

In chemical composition this allanite is somewhat variable, and in general low in rare earths. An analysis of a sample from two or three similar crystals, with about 1 percent impurities, made by Dr. R. B. Ellestad of the University of Minnesota, gave the following results:

	Wt. percent	*Mol. ratios*
SiO_2	34.30	.5711
Al_2O_3	22.18	.2178
Fe_2O_3	5.83	.0365
FeO	5.98	.0833
MgO	.48	.0119
CaO	16.81	.2997
$H_2O +$	1.46	.0810
$H_2O -$	.04	
TiO_2	.19	.0024
Ce_2O_3	5.81	.0177
R_2O_3	7.05 (other rare earths)	.0216 (La_2O_3)
Total	100.13	

A spectrographic examination of the same sample by Dr. T. G. Kennard showed that there were also present traces of the following elements: lithium, sodium, strontium, barium, copper, chromium, gallium, germanium, manganese, lead, titanium, vanadium, and zinc. Other samples yielded, in addition, traces of tin. The rare-earth residues from the analysis, kindly returned to Claremont by Dr. Ellestad, were found by Dr. Kennard to consist chiefly of cerium and lanthanum, with much smaller amounts of praseodymium, neodymium, and samarium, and a trace of yttrium. Other members of the yttrium subgroup were probably present, but in very small amount. Thorium was present in small amount, less than 1 percent of the rare-earth residue. It is concluded that R_2O_3 of the Ellestad analysis was mostly La_2O_3. The molecular ratios do not lead easily to a simple and satisfactory formula.

Other specimens studied spectrographically by Dr. Kennard and chemically by J. D. Laudermilk, had somewhat different compositions. In particular, one large crystal (called M) gave much stronger indications of lanthanum and other rare earths, and another lot yielded especially low values for the rare earths.

Optical properties of the Crestmore allanite are also somewhat variable. Crystal No. 4 was found by the single (temperature) variation method with sodium light, to have $\gamma = 1.7639 \pm .0005$ at 28° and $\alpha = 1.7460 \pm .0005$ at 45°, $\gamma - \alpha = .0179$.

The analysed material gave slightly higher indices, with $\gamma = 1.766 +$, $\beta = 1.7526$ and α about 1.749. Another lot gave $\gamma = 1.770 \pm .004$, $\beta = 1.757 \pm .003$ and $\alpha = 1.746 \pm .002$, with $\gamma - \alpha$ unusually high, .024. Other specimens from Commercial quarry have α as low as 1.734, and one unusually pale crystal from the mine, gray in color, gave $\alpha = 1.717 \pm .003$. $Y = b$ (tentative orientation); then $X \wedge \check{c}$ somewhat uncertain but perhaps $37° \pm 1°$. $X =$ pale brownish gray, $Y =$ rather dark smoky gray, $Z =$ nearly opaque. Positive, with 2V 80°–90°. One optic axis nearly $\perp$ (100), the big face. Large dispersion of the optic axes, usually $\rho > \nu$, sometimes apparently $\nu > \rho$, or ρ suppressed and ν yellow green. The isogyres are usually a series of color bands in white light.

Specific gravity of the allanite variable, probably ranging from 3.63 to 3.90. For crystal No. 10 from station 16, Commercial quarry, — 3.81, average of four very closely agreeing determinations (3.81 thrice, 3.82 once) made on a microbalance by Philip A. Vaughan, two with carbon tetrachloride and two with ethylene dibromide. Fusibility about 4, with intumescence, to a magnetic slag. Hardness 6 or 6.5.

Crystallographic, X-ray, and some optical data for the Crestmore allanite (treanorite) have not yet been brought into satisfactory agreement. It is hoped that future publication will include the crystallographic data already recorded by Dr. E. H. Bailey. Further work may show that treanorite is a new mineral, definitely distinguishable from ordinary allanite, but such a distinction will be possible only after allanite has been defined more precisely.

Foshagite. See Hillebrandite.

Forsterite. See Olivine Group.

Garnet Group. Most examples probably belong under grossularite, in spite of considerable variation, but one abundant occurrence, at least, seems to be an andradite.

Grossularite is the commonest contact mineral at Crestmore, as has been emphasized in previous papers. It frequently occurs in pure masses, some of which, when finely crystalline, have a sugary appearance, but when coarser, against calcite, may also show dodecahedral crystals up to several centimeters in diameter. Trapezohedral (*hll*) faces are rarer; they appear, for example, on a very pale green type, found with the yellow-brown form and with blue ceylonite near stations 13 and 14. Palest yellow, minute glassy garnets from a prehnite pegmatite near station 7 show dodecahedral and tetrahexahedral faces; they are slightly birefringent, with polysynthetic twinning and $n = 1.76 \pm$.

The various grossularites have not been specially studied, but indices have been determined ranging from $1.745 \pm .003$ to $1.780 \pm .010$.

The dark red-brown garnets associated with the dark green diopside in the quartz diorite contact zone on the west side of the Lone Star quarry appear from spectrographic data to be manganiferous grossularite-andradites. They develop many-faced crystals against limestone, with large dodecahedral faces bordered by narrow hexoctahedral and trapezohedral faces. The paler grossularites in the quartz monzonite porphyry contact zone, a hundred feet southeast in the same quarry, are simple dodecahedrons.

Andradite occurs abundantly near station 16 in a pegmatite composed of quartz, microcline, oligoclase, allanite (treanorite), and chloritized pyroxene. The simple dodecadedral crystals found here measure up to 2 centimeters in diameter, are semitransparent, and hair-brown in color. Spectrographic examination indicates a calcium-iron silicate, with aluminum subordinate to iron, and magnesium less than 1 percent. The refractive index, far above 1.74, and the specific gravity, 3.67 or a little higher, suggest an andradite containing 30 to 40 percent of the grossularite molecule.

Gehlenite. See Melilite Group.

Grossularite. See Garnet Group.

Hillebrandite, var. Foshagite. Chalky white, fibrous, relatively brittle. Found as (1) irregular masses up to 1 centimeter or more across, in idocrase rock near station 14; (2) near station 17 in veins 1 centimeter thick and 10 centimeters or more in length, intimately mingled with finely divided calcite in minor fault cracks, and closely resembling fine-grained amphibole asbestos; (3) the original type material of Eakle (12), which has again been found in the Wet Weather quarry as cross-fiber masses 8 to 10 centimeters in length, cutting greenish idocrase-rich rock. Some of the second type is so fine-grained that the indices of refraction and birefringence are intermediate between those of calcite and foshagite.

Humite Group. Deep yellow equidimensional crystals 3 to 10 millimeters across; locally abundant. For example, they spot the white limestone of the 910-foot level of Commercial quarry, as clear, glassy crystals without impurities of any sort. Magnesium (calcium) fluosilicate. Biaxial, positive, 2V 80°–85°, $\alpha = 1.625$, $\beta = 1.636$, and $\gamma = 1.655$. Slightly soluble in HCl. Probably chondrodite or clinohumite. Because of the uncertainty called Mineral O in 1941 (28). This mineral is common in other limestone bodies nearby in the city of Riverside. It weathers out easily, leaving rusty pits similar to those caused by the much commoner brucite.

Laumontite. See Zeolite Group.

Ludwigite. See Mineral B.

Melilite Group. Gehlenite has been found, but no akermanite.

Gehlenite was found near station 13, as grayish-white to black, granular streaks, interleaved with plazolite (?) in braided veinlets averaging about 1 millimeter in thickness; $\omega = 1.659 \pm .002$, some grains anomalously biaxial with 2V about 5°. Also, in the Wet Weather quarry, below station 5, in spurrite-merwinite rock, or as colorless or pale yellow, smooth, ½- to 1-millimeter glassy grains in bluish limestone (cf. Larsen and Foshag, 10). It also occurs with euhedral idocrase and custerite (Tilley, 14).

Mica Group. Pale or colorless *phlogopite* occurs in relatively large flakes in limestone near station 30 and at station 29, both in Wet Weather quarry; also in the south end of the Chino quarry, and in the mine. At the first locality, greenish to reddish brown plates several centimeters across were found in a single specimen of white limestone; at 29, more numerous smaller green plates; at the third locality, small brown crystals 1 millimeter or less in diameter, in limestone close to a contact with lavender, pyrrhotite-rich quartzite. From the Chino limestone of the mine, specimens of phlogopite measuring up to 4 centimeters in diameter have been obtained.

Colorless or pale green phlogopite is also found rather widespread as small grains in the limestone of Lone Star and Wet Weather quarries. Commonly it is associated with small idocrase crystals; at station 31 it occurs with Mineral B. $2V = 0°$; $\gamma = 1.583 \pm .002$.

Another very different type of mica in the limestone of Lone Star quarry is tentatively called phlogopite. This is a variety which is dark green in reflected light, though it has little color under the microscope. It was found by Richard Strehle at about 1800 N, 2200 E, as flakes and crystals 3 to 30 millimeters across, along with centimeter or larger crystals of pargasite (?), idocrase, and rarely pale pyroxene. The mica is negative, with $2V = 0°$; and $\gamma = 1.586 \pm .002$, $\alpha — 1.556 \pm .005$. The spectrograph shows it to be a magnesium-aluminum silicate, with a little iron, sodium, potassium, and calcium, and traces of lithium, barium, strontium, copper, chromium, gallium, manganese, lead, titanium, and vanadium.

Brown *biotite* is an abundant constituent of the quartz diorite and of lenses of mica schist in Commercial quarry and elsewhere.

Monticellite. See Olivine Group.

Olivine Group. Monticellite is very abundant; forsterite has not been found, although it is present in the Victoria limestone mass a few miles away.[7]

Monticellite was reported "of limited development and soon exhausted" by Eakle in 1917; and Daly listed it as rare in 1935. One type was described in detail by Moehlman and Gonyer (18). Our investigations have revealed monticellite in a wide range of color, abundantly present, in all the quarries except the Chino limestone quarries on the west side of Sky Blue Hill. It is commonly associated with blue calcite and with all the contact rocks owing their origin to the quartz monzonite porphyry intrusion, except wollastonite and garnet rocks. Even with these latter minerals, direct association has been observed by Moehlman and Gonyer (18). Monticellite occurs most abundantly between idocrase-diopside rock and blue calcite, frequently extending into each.

The commonest variety is massive and granular, usually pale to dark brown in color, more rarely practically colorless. The largest mass is present in Wet Weather quarry near station 29 (fig. 6). Also at station 14, Commercial quarry; and at station 13—pale gray, with pink wilkeite and white crestmoreite. Blocks from the ridge northwest of station 8 show this variety, with custerite, forming the matrix of pale idocrase crystals (cf. Tilley, 14). In Lone Star quarry it occurred in large quantity as nodular masses from 2 inches to 18 inches in diameter, which look like boulders or concretions. None were found in matrix. Some of the nodules, when broken, are found to contain inclusions of green idocrase; others change from brown to gray and colorless monticellite within, and contain blue calcite with crestmoreite in the center. The crestmoreite is often seen in the monticellite also.

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[7] Laudermilk, J. D., and Woodford, A. O., Hydrous iron sulphide in California crystalline limestone: Am. Mineralogist, vol. 25, pp. 418-424, 1940.

The brown variety of monticellite occasionally forms prismatic crystals extending into the blue calcite, fine ones having been found at the Wet Weather and Commercial locations mentioned above. One 15 by 17 millimeter crystal from station 14 shows (110) and (111) forms.

At station 14, Commercial quarry, pale yellowish and colorless monticellite occurs with spurrite and gehlenite. Also a rarer distinctly yellow type fills spaces in idocrase, associated with foshagite.

On the new 910-foot level of Commercial quarry, gray, vitreous, 10- to 20-millimeter grains and crystals of monticellite occur in bands in the limestone near yellow wilkeite. The brown variety also occurred here with blue calcite and green xanthophyllite crystals.

Monticellite (the Mineral "A" of Larsen and Foshag, 10) is also a constituent, with merwinite, etc., of the rather fine-grained gray-green spurrite rock, which is so abundant along the southeast margin of the limestone in Lone Star quarry. Great blocks of this rock have fallen into Wet Weather quarry, and it may also have occurred in place there.

Optically the various color varieties of monticellite are similar, with $\beta = 1.645–1.653$, $\gamma - \alpha = .014 \pm .003$, sign negative with $2V = 80°–85°$. $G = 3.06–3.11$. The mineral is soluble in hot concentrated HCl, and yields appreciable amounts of iron and aluminum, in addition to the predominant calcium, magnesium, and silicon.

MONTMORILLONITE. Soft, white and waxy clay-like material associated with calcite and granular prehnite in a 4-inch vein along a N. 30° E. drift on the 700-foot level of the mine beneath the Chino quarry.

OPAL. (1) Colorless hyalite, more abundant than was indicated by Eakle (4). Commonly found as a coating on joint-planes, especially in garnet rock near station 12. (2) Brownish to black, banded "wood-opal," found in quantity near station 18, as the replacement of travertine, altered garnet, monticellite, and fault-gouge materials.

PLAZOLITE (?). At station 14, white, fine-grained masses of a hydrous calcium-aluminum silicate, containing some magnesium and iron, alternating in a braided structure with gehlenite. Somewhat opal-like in luster. Isotropic, $n = 1.675 \pm .005$. This material may or may not be the same substance as the minute, colorless or light yellow dodecahedral crystals described by Foshag (8). Probably the small amount of CO_2 shown by Foshag's analysis is not essential. In a letter dated August 2, 1940, Foshag states that the CO_2 may have come from included calcite. Pabst (23) ignored CO_2 in determining the crystal structure.

PREHNITE. Found rather abundantly near stations 8 and 9 in semi-transparent green to white or brown crystalline masses, and in distinct, colorless 1 by 3 millimeter crystals showing prominent (001), (110), and (101) faces; also common in crystalline aggregates which exhibit the usual "corrugated" surfaces. $\beta = 1.627 \pm .003$. In pegmatite, with oligoclase, quartz, datolite, and treanorite.

PYROXENE GROUP. Diopside is very common in the contact rock. Pyroxene grains are characteristic of the quartz monzonite porphyry; they have not been studied sufficiently for more precise definition. The pyroxene crystals sometimes present in pegmatite are usually much altered.

The very pale yellowish *diopside* described by Eakle (4) and Merriam and Laudermilk (21), with $\alpha = 1.666$ and $\gamma = 1.695$, was especially abundant in Lone Star quarry. Good crystals up to 7 centimeters in length projected into blue calcite. A grass-green variety, +, $2V = 55°–60°$, $\alpha = 1.670 \pm .003$, $\gamma = 1.703 \pm .003$, occurred as grains in calcite east of the present face in Commercial quarry. The pale green pyroxene so abundant in the garnet rock usually has higher indices, e.g. $\alpha = 1.688 \pm .003$ for a specimen from the top of Sky Blue Hill above station 9.

PYRRHOTITE. Fairly common in the Wet Weather quarry, the Chino quarry and the mine workings. In western Wet Weather quarry disseminated through limestone; also present above station 29 as lenticular masses 1 centimeter or more across in a monticellite-idocrase rock. At the Chino quarry, it is found widespread granular or as crystals, especially distributed in small amounts throughout the quartzite. From the mine beneath, pyrrhotite masses weighing more than 500 pounds have been obtained occasionally, sometimes associated with "black-jack" sphalerite.

Riversideite. See crestmoreite discussion.

Scapolite. Good crystals of translucent to cloudy white scapolite, measuring 1 by 4 centimeters and showing well-developed (110), (100), and (111) faces, occur near station 15, with blue-gray calcite in garnet rock. $\omega = 1.566 \pm .001$ perhaps indicates *dipyre*. Also massive, in contact rock at station 13; ω variable, 1.553–1.576; $H = 5.5$. Fine-grained scapolite has been found with brown tourmaline in a Wet Weather block of fine-grained contact rock; its indices, $\omega = 1.582 \pm .002$, ε approximately 1.550, indicate *mizzonite*. Scapolite (*dipyre?*) was probably abundant locally in mixed rock and pegmatite, but is hard to identify because of alteration.

Sepiolite (?). A loose block of white diopside-calcite rock, found by Richard Strehle in Lone Star quarry, at 1800 N, 2200 E, has one surface covered by rosettes of sepiolite (?), in coarse fibers 2 or 3 centimeters long. A preliminary analysis by J. D. Laudermilk showed this to be a hydrous magnesium silicate, insoluble or only slightly soluble in HCl. Microscopic study by M. P. Yackel showed one good cleavage parallel to elongation; biaxial, probably negative with rather small 2V; fibers with parallel extinction and positive elongation; $\alpha = 1.541$, γ about 1.560.

Sepiolite was definitely reported by Daly (19).

Sphene. Golden yellow, millimeter crystals of sphene are very abundant in some pegmatites. Larger brown crystals are also fairly common. A cavity in garnet rock, lined with brown sphene crystals, has been found in the southeast face of the Lone Star quarry by Mr. R. E. Campbell of Bloomington. The crystals are 5 to 10 millimeters across, and show the common flat double wedge habit. Coarse, massive gray calcite has been partially dissolved from the cavity and much coarse massive albite remains. This sphene may be hydrothermal.

Spinel. The dark blue-green variety of spinel known as "ceylonite" has been found near station 14, where it occurs as translucent grains 1 to 4 millimeters in length, with pale green grossularite garnet and granular calcite. The wilkeite-bearing limestone of the 910-foot level is locally peppered with smaller, very dark green, nearly black, spinel octahedrons.

Spurrite. (1) Pale bluish-gray and snowy, to deep sky blue and clear. Rather abundant, in masses 1 to 10 centimeters across. With calcite, idocrase, etc., above station 29 (Wet Weather quarry), with gehlenite near stations 13 and 14 in Commercial quarry, and in blocks from the top of the ridge above station 8. (2) In compact, pale to dark green, granular masses of widely varying sizes, near station 29. (3) Perhaps the most abundant constituent of the greenish-gray spurrite-gehlenite-merwinite rock which makes up a considerable part of the contact rock above the southeast corner of the Lone Star quarry.

Stilbite. See Zeolite Group.

Strontianite. Found in Lone Star quarry as white, tufted fibers in minute balls on a joint surface.

Talc (?). Talc is doubtfully present as a minor constituent of a rock with brown tourmaline in Wet Weather quarry. Colorless flakes with hardness about 2; $2V = 26° \pm 4°$; $\alpha = 1.548 \pm .005$, $\beta = 1.587 \pm .002$, $\gamma = 1.589 \pm .002$.

Thaumasite. Abundant in Lone Star quarry and elsewhere in veinlets cutting spurrite rock as described by Foshag (7) and Larsen and Foshag (10). Also with calcite and crestmoreite forming the white silky matrix of some idocrase crystals from the Wet Weather quarry.

Thulite. See Epidote Group.

Tourmaline. Schorl has been found rather rarely in trigonal prisms up to 10 centimeters in length in the quartz monzonite porphyry pegmatites, and thin, platy crystals 3 or 4 centimeters long in seams. It is more abundant in the pegmatites associated with the quartz diorite.

Brown tourmaline prisms spotted a block of gray scapolite-bearing contact rock in Wet Weather quarry; ω = chocolate brown, $1.650 \pm .002$; ε = pale greenish tan, $1.625 \pm .005$.

Treanorite. See Epidote Group.

Tremolite (?). See Amphibole Group.

Vermiculite. Near station 18, brown to black plates up to 15 millimeters in diameter, probably derived by hydration from biotite. The mineral associations are pegmatitic in character, and schorl is prominent.

WILKEITE. On the basis of information furnished by Mr. R. M. Wilke of Palo Alto, under date of November 29, 1940, we conclude that the original find of wilkeite, in blue calcite with idocrase, was made in the north central part of Commercial quarry, slightly north of east of the summit of Sky Blue Hill, near 1650N 2700E, Riverside Cement Company coordinates. The mineral is now very rare in the main Commercial quarry. A few rose-colored grains with crestmoreite rims were found with monticellite at station 13. It still occurs in limited amount in the Wet Weather quarry above station 29, in typical pale rose-colored grains up to 3 millimeters across, associated with crestmoreite. Uniaxial, negative, $\omega = 1.651 \pm .001$; $\omega - \varepsilon$ approx. .009 at station 13, .005 at station 29. In November 1940, pink hexagonal crystals 5 to 10 millimeters wide were found alongside giant wollastonite crystals in blue calcite, a few centimeters from idocrase contact rock, in great blocks which fell into Wet Weather quarry from the ridge southwest of Lone Star quarry. These crystals are uniaxial, negative, with $\omega = 1.657 \pm .001$, $\varepsilon = 1.648 \pm .002$, and may be ellestadite (24). Still more recently, numerous patches and veinlets of similar pink wilkeite have been found in Wet Weather blocks which fell from the steep wall just northwest of station 8 (fig. 6).

A yellow variety (wilkeite?) occurs as numerous distorted crystals and wheat-shaped grains on the 910-foot level of the Commercial quarry, where it is associated with calcite, glassy gray monticellite, crestmoreite, idocrase, etc. The yellow variety is biaxial, with 2V commonly 38° ± 2°, as estimated from interference figures. It is tentatively called wilkeite rather than a related mineral, as it is a calcium phosphate-carbonate-silicate-sulphate, with low birefringence and $\gamma = 1.647$ to 1.650.

WOLLASTONITE. In addition to the numerous occurrences of the massive mineral, well-formed crystals have recently been found at two localities. Near station 14, 1 by 2 centimeter crystals show the forms (001), (101) and (100), the associated minerals being blue calcite and grossularite. Blocks with yard-broad surfaces covered by even better crystals have tumbled down from the ridge southeast of Lone Star quarry. These crystals have not been studied, but they apparently belong to Eakle's second type (4, p. 334).

XANTHOPHYLLITE. A specimen of light green "waluewite" associated with pale diopside, from the University of California Crestmore collection and presumably part of Eakle's (3) material, was kindly loaned by Professor Adolf Pabst. It is brittle and hard (4.5 or 5); $2V = 12° \pm 2°$; β and $\gamma = 1.660 \pm .003$; α probably between 1.645 and 1.650.

Similar material and also paler green or even colorless pseudohexagonal crystals and irregular flakes have been found in recent years at a spot well known to many collectors, the "xanthophyllite locality" in Commercial quarry 50 feet northwest of station 14. The flakes are commonly small, usually less than 3 millimeters in diameter. The rarer stepped or striated crystals may be a centimeter high and a centimeter across. Associated minerals are pale greenish-yellow diopside, brown idocrase and blue calcite. The xanthophyllite is brittle, with hardness close to 4; 2V 0° to about 23°, β and γ 1.656 to about 1.665.

Green xanthophyllite crystals up to 20 millimeters across were found by Richard Strehle on the south-central face of upper Lone Star quarry, and were studied by him and Dr. Kennard. The associated minerals were magnetite, diopside, and idocrase, all in a calcite zone in idocrase rock. Spectrographic analysis showed much silicon, calcium, magnesium, and aluminum as well as a little iron, and traces of lithium, sodium, barium, strontium, copper, chromium, gallium, manganese, nickel, titanium, and vanadium. Optically negative, with 2V 2°–26°; $\gamma = 1.66$. Green color close to that of the softer, flexible phlogopite (?) found farther out in the limestone of the same quarry.

ZEOLITE GROUP. Zeolites or similar minerals are quite common at Crestmore, especially in the quartz monzonite porphyry pegmatites. Laumontite is abundant, phillipsite and stilbite have been identified, and several other species are probably present.

Laumontite is probably the commonest zeolite at Crestmore. Found in pegmatite dikes and pegmatite-like calcite-bearing masses, such as occur near stations 9 and 11, where it is seen as white, friable masses (variety caporcianite), or interlacing crystals varying greatly in size. Also in more compact masses of radiating or parallel columnar units 3 to 8 millimeters in length, and as 5-millimeter crystals in cavities, showing the forms (110) and (001). Optically variable; γ ranges from 1.515 to 1.526. In one case great dispersion $\varrho > v$. The caporcianite variety has $\gamma = 1.515$–1.517 and extinction of 40°–42° on cleavage pieces.

Phillipsite is found very rarely on joint surfaces as lustrous silky-white, spherical or divergent, radiate groups of crystals 15 to 20 millimeters in length: (1) near station 15 on contact rock composed of scapolite, blue calcite, and cinnamon garnet; (2) on blue limestone of the 910-foot level. $\gamma - \alpha = .005$; indices close to 1.500. Fibers show $Z \wedge c$ 6°–10°. $H = 4.5$; $G = 2.16$; $F = 2$. Hydrous aluminum silicate, gelatinizing with HCl.

Stilbite is very rare. In the pegmatite near station 15, in transparent, platy crystals up to 1 centimeter in length, with the familiar divergent structure and characteristic pearly luster. $\alpha = 1.493 \pm .002$. $\gamma = 1.504 \pm .003$.

Zircon. 1- to 3- millimeter gray to brown zircon crystals, associated with oligoclase and other minerals of the pegmatites, near stations 8, 9, and 15 (cf. Foshag, 8).

Zoisite. See Epidote group.

New or Undetermined Minerals

In the Pomona College collection there are 25 or 30 Crestmore minerals not definitely identified with named species. Some of these were given letters by Woodford, Crippen, and Garner (28), and these are briefly described below.

Mineral B. Slender, black orthorhombic prisms up to 20 millimeters in length have been found in the Sky Blue limestone (e.g. at station 31, Wet Weather quarry) as well as at Victoria City quarry in Riverside. Chemical analysis of a very small sample by J. D. Laudermilk shows that this mineral is an aluminous iron-magnesium borate which may be closely related to ludwigite. It is strongly pleochroic: X = pale green, Y = slightly darker green, Z = dark brown. $\alpha = 1.791$, probably $\pm .002$; $\gamma - \alpha = .095 \pm .010$. Crystallographically it seems to have the proper prism angles for ludwigite. In addition, there are numerous sharp terminal forms not previously reported on ludwigite. Dr. Edgar H. Bailey hopes to be able to describe this occurrence more completely.

Mineral C. Small white radiating groups of fibers locally developed in an inch-thick sheet of calcite and wollastonite in Lone Star quarry contact rock. A hydrous calcium-aluminum silicate with $\alpha = 1.545 \pm .002$, and $\gamma = 1.549 \pm .002$. The fibers show parallel extinction and positive elongation. This appears to be a new mineral and it may be possible to obtain sufficient material for chemical analysis and a more exact determination of the optical and other properties.

Mineral D. A second white mineral occurring in radiating groups 5 to 10 millimeters across, with wollastonite, in a pegmatitic vein in Lone Star quarry, is a hydrous calcium-magnesium silicate with minor aluminum. Parallel extinction; + elongation. For the fresh material, $\alpha = 1.513$ and $\gamma = 1.532$. After a summer in the laboratory: $\alpha = 1.518 \pm .002$, $\gamma = 1.536 \pm .002$. As no zeolite has this composition or these properties, the mineral is considered new.

Mineral F. A secondary mineral, occurring as definitely crystalline blue films coating joint planes of the quartz monzonite porphyry and contact rock near the southern end of Commercial quarry. It is a copper-calcium-aluminum silico-carbonate with low birefringence and indices close to 1.70. This mineral is rather certainly new but occurs in such small quantities that it may not be possible to obtain sufficient material for a chemical analysis.

Mineral G. The yellow wilkeite and white crestmoreite now exposed on the 910-foot level of the Commercial quarry are in some places accompanied by centimeter-long brownish-black pseudomorphs of a monoclinic mineral. Apparently identical pseudomorphs have also been found in Lone Star quarry. The principal mineral present appears to be a hydrous magnesium-aluminum silicate containing some calcium and iron. Optical properties are similar to those of an impure, iron-stained clay mineral, with low birefringence and indices mostly between 1.535 and 1.545. In one case monticellite cores are present but the original monoclinic mineral is more likely to have been a diopside or chondrodite. The angles measured on one or two well-preserved pseudomorphs are fairly close to those published for chondrodite but do not fit diopside. Murdoch and Webb (26, p. 350) have reported somewhat similar pseudomorphs, with forms suggesting diopside.

Mineral H. Described (28) as a titanium-rich tourmaline, with indices well above 1.74. In a letter received by the author in July 1941, Dr. Waldemar Schaller asked if this could possibly be warwickite. Later, when H. Stanton Hill and the author checked over the Pomona College specimens, they failed to find any authentic example of Mineral H, and only two spurious specimens (schorl), instead of the four or more supposed specimens which the author saw in 1940 or 1941. They could not even find certain records of pertinent chemical and optical determinations. These records were with the specimens in 1941, and apparently all were misplaced together. Mineral H must be considered still-born.

Mineral J. A white silky radial mineral associated with Mineral G on the 910-foot level of Commercial quarry. $\alpha = 1.551$, $\gamma = 1.553$; extinction parallel, elongation positive. A hydrous calcium silicate with some aluminum present. Perhaps okenite.

Mineral K. Associated with Mineral P on joint surfaces of the contact rock on the 910-foot level, Commercial quarry. Glassy, stout, hexagonal prisms with good terminations, and good prismatic cleavages. Angle of 47° 23′ ± 30′ between basal pinacoid and hexagonal pyramid. Uniaxial, negative, $\omega = 1.494 \pm .002$, $\varepsilon = 1.467 \pm .003$. Calcium-aluminum silico-carbonate. Alters, after a few hours' or days' exposure, to snowy white pseudomorphs with lower indices and less double refraction, α finally becoming about 1.459 and γ 1.466. The alteration may be due to a change in water content, as the product seems to be still a silico-carbonate.

Mineral L. Minute, chalky, white, tetragonal crystals occurring in the andradite-allanite pegmatites at the south end of the Commercial quarry, especially obvious as inclusions in andradite. Professor Joseph Murdoch, who has also secured examples of this mineral, recognized the following forms: (001), (110), (100), (111), (113), (101). The ϱ angles were 63° (111), 32° (113), 55° (101). The crystals are altered to a fine-grained crystalline aggregate with indices slightly below 1.64. Impure calcium-thorium silicate, perhaps close to thorite, perhaps a new mineral.

Mineral M. Isotropic yellow particles included in Mineral L. Index $1.520 \pm .002$.

Mineral N. Yellow-green films on joint planes of the rocks in Lone Star quarry and elsewhere, which prove to be lead-copper-calcium vanadate. The indices of refraction and the double refraction are both extremely high. This is either a new mineral or perhaps a mixture of known vanadates.

Mineral O. See Humite Group.

Mineral P. A colorless calcium-aluminum-magnesium fluosilicate occurring as crusts and crystals in cracks of the limestone of the 910-foot level of the Commercial quarry, associated with Mineral K.

Mineral P occurs massive and also as druses of numerous small triclinic crystals with many smooth faces. The axial elements are not close to those of any triclinic mineral with similar composition. Biaxial, +, 2V 35°–40°. $\alpha = 1.613 \pm .003$, $\beta = 1.619 \pm .002$, $\gamma = 1.630 \pm .002$. One excellent cleavage nearly normal to optic axial plane. Dr. Edgar H. Bailey expects later to name this mineral and to publish a detailed description of it, including the extensive crystallographic data which he has already collected.

Mineral Q. Soft, white, silky fibers, in cavities in limestone blocks found in Wet Weather quarry. A calcium silicate. Isotropic, $n = 1.482$.

MODE OF OCCURRENCE OF CONTACT AND OTHER MINERALS

In the contact zone good crystal faces against calcite are shown by several minerals, especially wollastonite, diopside, idocrase, garnet, and Mineral B. Diopside, phlogopite, idocrase, Mineral B and Eakle's second type of wollastonite (4) are present as more or less perfect crystals isolated in calcite near silicate contact zones. More commonly diopside and garnet crystals project into calcite from masses of contact rock. Garnets are rarely, if ever, complete crystals. Idocrase also has formed perfect pyramidal crystals in a silicate matrix of monticellite and custerite. Perhaps the greatest range in crystal size is shown by idocrase pyramids, which are very abundant in the millimeter size and which sometimes, though rarely, reach diameters of 100 or even 200 millimeters.

Some details concerning crystal forms have been given in the notes on individual minerals.

Pseudomorphs of brucite after periclase, and crestmoreite after wilkeite are well known at Crestmore, and the products of the alteration are abundant. There are also several other cases, including laumontite after feldspar, and even garnet after idocrase. The pyramidal garnet pseudomorphs, from station 15, Commercial quarry, have the refractive index 1.747 ± .005, which suggests almost pure grossularite.

Perhaps the most striking vein mineral is the white thaumasite which occurs in seams and thicker sheets cutting spurrite-merwinite rock. Foshagite is usually in cross-fiber veins in idocrase-rich rock. Other vein minerals include aragonite and strontianite, both perhaps quite recent crystallizations. Minerals C, D, K, P, and Q are also vein minerals, cutting contact rock.

The carbonate and sulphate ore minerals listed in Table 1 are commonly associated with sulphides and are obviously oxidation products.

Nontronite, vermiculite, montmorillonite, kaolinite (?), and opal are alteration products, in part at least due to weathering. Weathering has also produced manganese stains, not represented in Table 1 because their mineral identity was not determined. Minerals F and N are probably products of weathering.

SUGGESTIONS FOR FURTHER WORK

The 1941 (28) and present papers are merely reports of progress in the study of Crestmore minerals. Dozens of specimens in the Pomona College collection are unidentified or doubtfully determined. Several species are rather certainly new, and should be described. More study should be given to such old species as crestmoreite-riversideite, chondrodite (?), monticellite, and the members of the apatite and zeolite groups. When the descriptive mineralogy is finished, the even more interesting problems of origin can be attacked.

Our group of workers has been broken up and it is unlikely that a similar group will be reassembled in Claremont. We hope that others elsewhere will bring the study of Crestmore minerals to a more satisfactory conclusion.

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THE ISOMETROGRAPH AS DEVELOPED AND USED AT THE NEW IDRIA QUICKSILVER MINE *

By J. McLaren Forbes **

OUTLINE OF REPORT

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INTRODUCTION

As a result of an extensive geological investigation of the New Idria quicksilver mine, Idria, California, a mass of data has been gathered and recorded upon separate mine maps of the various levels. The complex geology, especially difficult to understand when plotted only on separate two-dimensional mine maps, called for an assembled three-dimensional master block diagram to correlate all available data.

Since the workings at Idria are quite extensive—more than 20 miles of underground openings—it is evident that the task of plotting by hand such a block diagram would be long-drawn-out and tedious, and that some mechanical means, such as those described by Johnston and Nolan[1] would save time and expense. After studying various devices, the Van der Hoop[2] type of instrument was chosen because of its simplicity of construction and operation. This instrument, called the isometrograph, was made in the mine shop, and was found to be accurate and easy to operate. Its usefulness has exceeded all anticipations. The final diagrams prepared by the use of this instrument have served to correlate and place the geologic data in such a manner that the underground relationships of orebodies can readily be understood. As a result of this clearer understanding, new orebodies of great economic significance have been discovered.

It is hoped that the following description of the isometrograph and its employment may serve others equally well in the examination and development of mining properties.

THE ISOMETROGRAPH

The isometrograph consists of a four-arm link system, two sliding blocks, a rod for the fixed track, a tracing stylus, and a copy pencil.

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* Published by courtesy of Mr. C. Hyde Lewis, mine manager of the New Idria Quicksilver Mining Company, Idria, California.

** Geologist, New Idria Quicksilver Mining Company. Manuscript submitted for publication October 3, 1943.

[1] Johnston, W. D., Jr., and Nolan, T. B., Isometric block diagrams in mining geology: Econ. Geology, vol. 32, pp. 550-569, 19 figs., 1937.

[2] Johnston and Nolan, op. cit., pp. 565-568.

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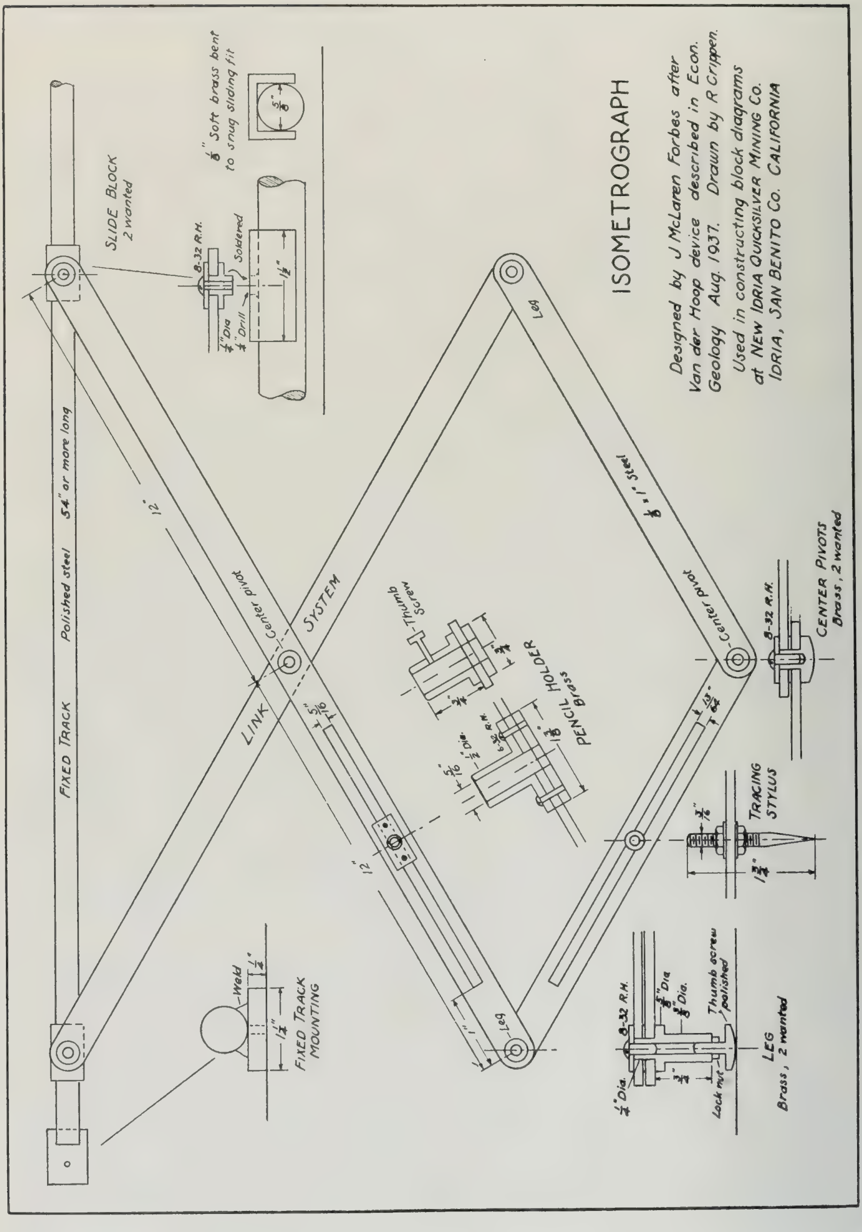
FIXED TRACK
Polished steel
54" or more long
SLIDE BLOCK
2 wanted
8-32 R.H.
Soldered
1/4" Dia
1/4" Drill
1 1/2"
1/8" Soft brass bent to snug sliding fit
5/8"
12"
Center pivot
LINK
SYSTEM
5/16"
12"
1"
Leg
Leg
Thumb Screw
3/4"
1/4"
PENCIL HOLDER
Brass
1 3/8"
6-32 R.H.
1/2" Dia.
5/16"
1/8" x 1" Steel
Center pivot
13/64"
ISOMETROGRAPH
Designed by J McLaren Forbes after Van der Hoop device described in Econ. Geology Aug. 1937. Drawn by R Crippen.
Used in constructing block diagrams at NEW IDRIA QUICKSILVER MINING Co. IDRIA, SAN BENITO Co. CALIFORNIA
8-32 R.H.
CENTER PIVOTS
Brass, 2 wanted
TRACING STYLUS
3/16"
1 3/4"
Weld
1/4"
1 1/4"
FIXED TRACK MOUNTING
8-32 R.H.
1/8" Dia
3/8" Dia.
Thumb screw polished
1/4" Dia.
3/4"
Lock nut
LEG
Brass, 2 wanted

Fig. 1. The isometrograph. Specifications and design.

The link system is connected to the fixed track by means of the sliding blocks.

Constructional details of the isometrograph are shown on the accompanying drawing prepared by R. A. Crippen. Sliding blocks of the kind shown were tried and found to be more satisfactory than the bushing type. The length of the fixed track depends on the size of the drawing table available but should be at least 60 inches and of sufficient diameter to be rigid. All bearings and bushings should fit snugly and operate freely.

The isometrograph made at Idria is so designed that not only isometric (120°) tracings can be made, but also tracings based on angles from about 100° to more than 135°. This is accomplished by changing in their slots the positions of the tracing stylus and copy pencil, which must always be placed along a line perpendicular to the fixed track (fig. 2). As the stylus follows a 90° angle bisected by this perpendicular, the copy pencil describes the larger angle of the projection; if the stylus describes a circle, the copy pencil draws an ellipse. Thus, while the tracing stylus follows the original plan, the copy pencil produces a new drawing in perspective.

THE BLOCK DIAGRAM

The finished block diagram consists of a drawing in perspective of a series of blocks shown one above the other, the horizontal surface of each representing a separate mine level. In the construction of these blocks, it is first necessary to prepare a series of maps of each level re-drawn in perspective. Outlines of these horizontal plans are placed on one drawing so that they appear to lie one above the other. Then they are connected by vertical lines to complete the shapes of the blocks. It is in the re-construction of the original maps of the mine levels to form isometric tracings that the mechanical device, the isometrograph, is employed.

DEFINITION OF ISOMETRIC PROJECTION

As Lobeck[3] says:

> "Isometric projection or perspective is not a true perspective but for some purposes it is much more useful. As the term 'isometric' connotes, the projection has dimensions along certain directions which are commensurate with each other. All of these dimensions in spite of being taken along different directions, may be made equal to the measurements along the corresponding directions in the actual block which is being put into perspective, or if not equal at least they may all be made on the same proportionate scale of the original." . . . "In the isometric block parallel lines are drawn parallel and all measurements along the three main co-ordinates are comparable and can be transferred directly from the original plan or elevation . . ."

The angles at the corner of the block are generally chosen to be 60° and 120°. Other angles are sometimes employed, but in any case the sum of all corner angles must be 360°. Johnston and Nolan[4] state:

> "It can be safely said, however, that the novice in constructing block diagrams had best begin with an isometric projection and depart from it only in special cases. A perspective projection of a mine is rarely worth the increased constructional labor, and in addition, in perspective projections it is difficult to scale or compute distances from one point to another in the diagram."

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[3] Lobeck, A. K., Block diagrams, John Wiley and Sons, Inc., p. 119, 1924.

[4] Op. cit., p. 552.

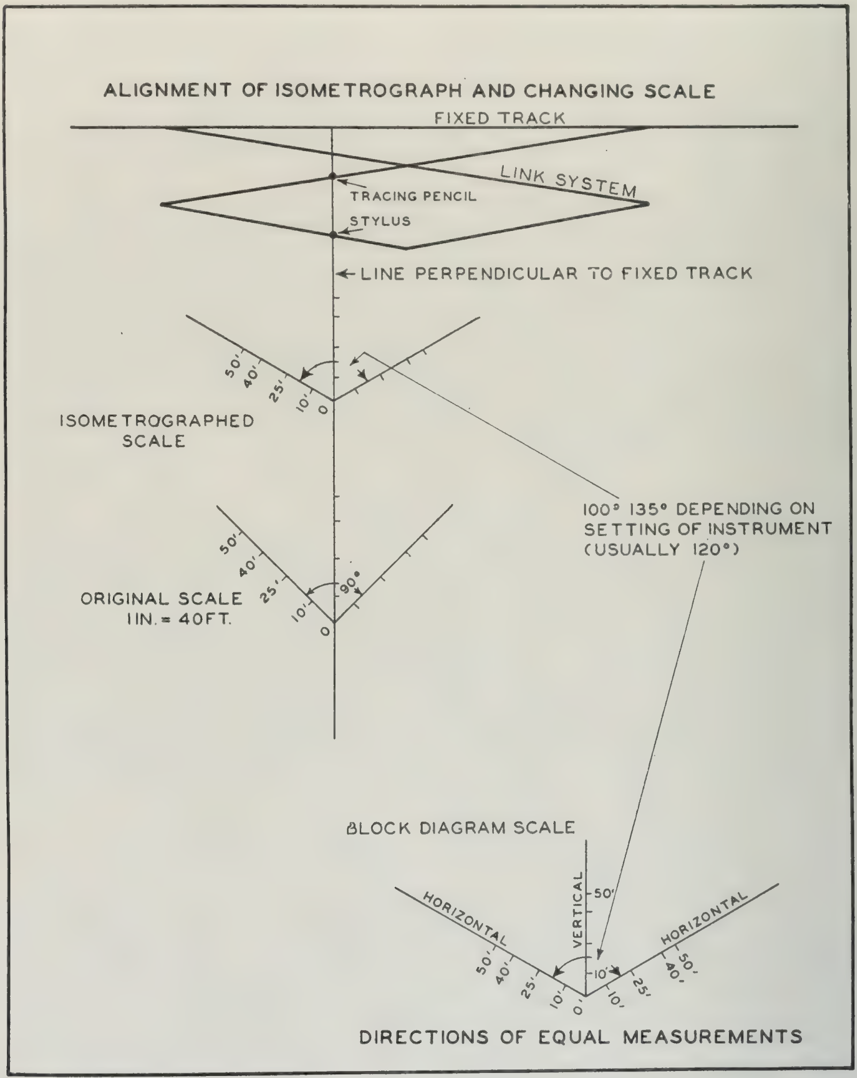
ALIGNMENT OF ISOMETROGRAPH AND CHANGING SCALE
FIXED TRACK
LINK SYSTEM
TRACING PENCIL
STYLUS
LINE PERPENDICULAR TO FIXED TRACK
50'
40'
25'
10'
0
ISOMETROGRAPHED SCALE
100° 135° DEPENDING ON SETTING OF INSTRUMENT (USUALLY 120°)
50'
40'
25'
10'
0
90°
ORIGINAL SCALE 1 IN. = 40 FT.
BLOCK DIAGRAM SCALE
VERTICAL
50'
10'
HORIZONTAL
HORIZONTAL
50'
40'
25'
10'
0'
10'
25'
40'
50'
0
DIRECTIONS OF EQUAL MEASUREMENTS

FIG. 2. Diagram to show position and adjustment of the isometrograph. The stylus and copy pencil must always be in a line perpendicular to the fixed track. This line bisects the 90° angle in the original pan. In the isometrographed tracing, however, the corresponding angle described during operation of the instrument is greater than 90°. Usually 120° is the angle chosen for the projection. This angle is obtained by shifting the stylus and copy pencil to the right or left until the proper place is established. The scale relationship is shown between the original plan, the isometrographed drawing in perspective, and the final block diagram.

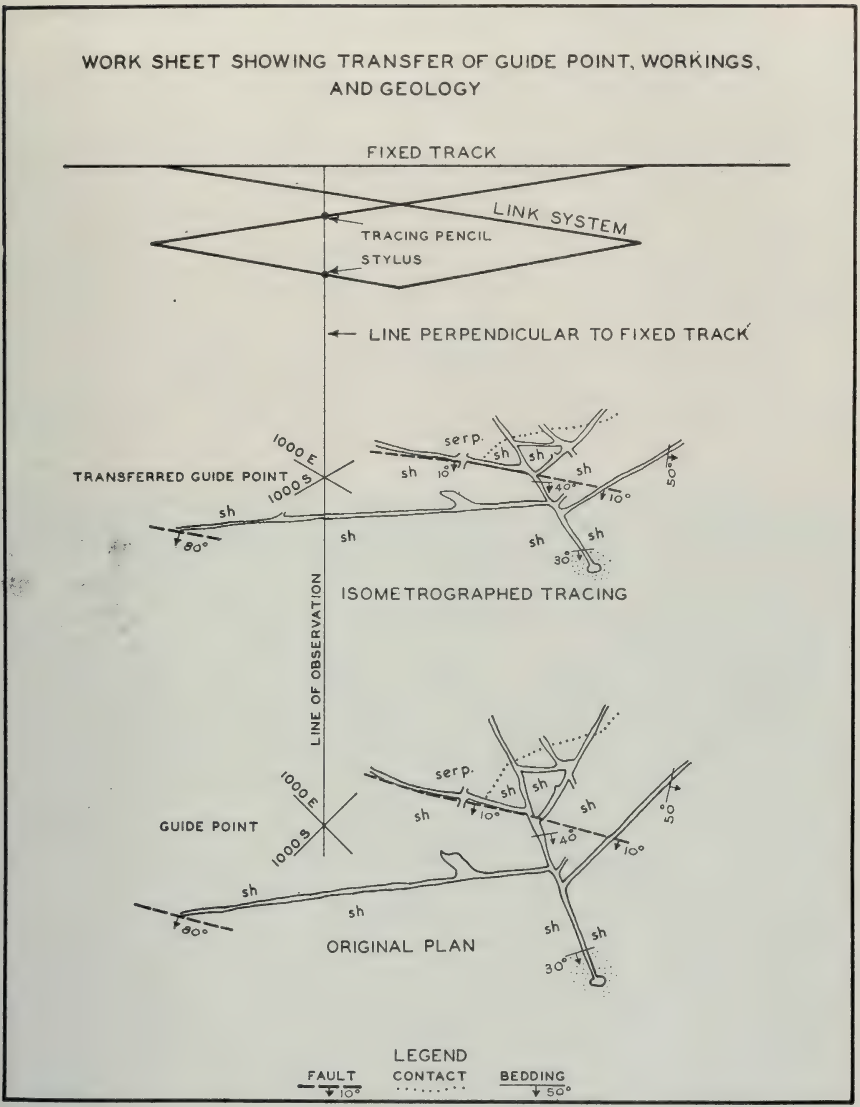
WORK SHEET SHOWING TRANSFER OF GUIDE POINT, WORKINGS, AND GEOLOGY
FIXED TRACK
LINK SYSTEM
TRACING PENCIL
STYLUS
LINE PERPENDICULAR TO FIXED TRACK
1000 E
1000 S
TRANSFERRED GUIDE POINT
serp.
sh
10°
40°
50°
80°
30°
ISOMETROGRAPHED TRACING
LINE OF OBSERVATION
GUIDE POINT
ORIGINAL PLAN
LEGEND
FAULT
CONTACT
BEDDING

FIG. 3. Diagram to show position of isometrograph to the two corresponding drawings of a mine level. The original drawing is printed on a piece of paper large enough to accommodate the isometrographed tracing obtained during operation of the instrument.

Six general rules are given by Lobeck[5] which should be followed in making isometric projections. They are:

"1. Measurements may be made to scale anywhere upon the upper surface of the block in the direction of either of the two co-ordinates, which in the object itself are at right angles to each other.

"2. Distances in other directions are not commensurate with each other unless measured along lines parallel to each other, and they are not commensurate with distances measured on the sides of the block.

"3. All lines parallel in the object itself are parallel in the isometric drawing.

"4. All lines vertical in the object are vertical in the drawing.

"5. If the vertical scale of the drawing is the same as its horizontal scale, then the measurements made in the direction of any of the three co-ordinates are commensurate.

"6. All angles in an isometric drawing are distorted, and even two angles lying in the same plane can not be compared with each other unless they lie in exactly similar positions."

PROCEDURE IN MAKING THE BLOCK DIAGRAM

The construction of the block diagram requires (1) the preparation of isometrographed drawings of each mine-level map, (2) the establish-

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[5] Op. cit., pp. 120-121.

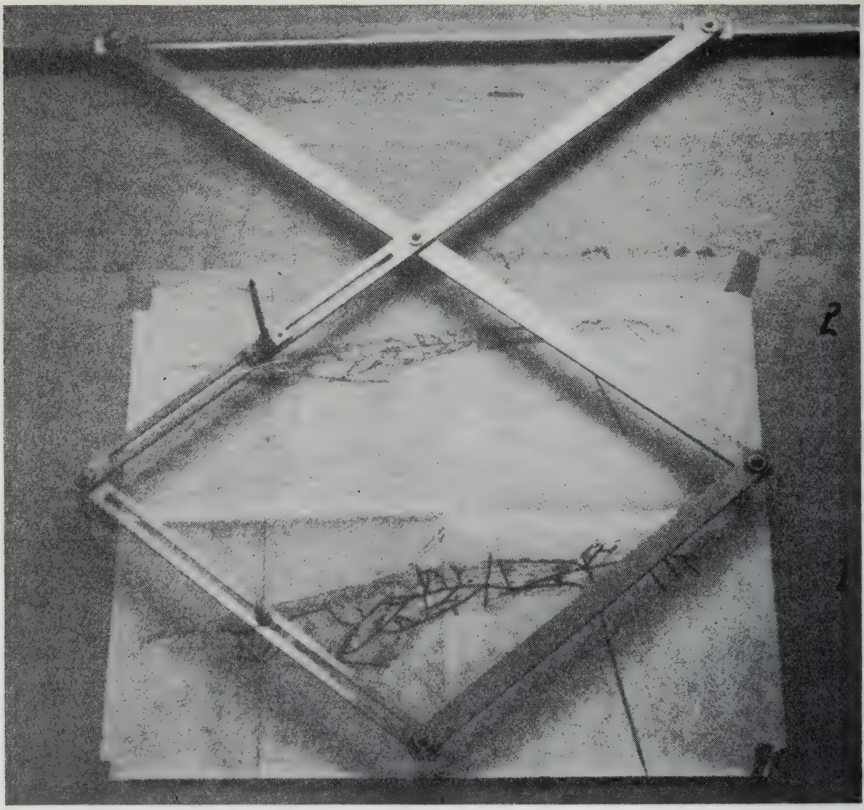

FIG. 4. Photograph of the isometrograph in operation. Drawing No. 1 is the original plan of a mine level. Drawing No. 2 is obtained through operation of the instrument; it is the isometric projection.

ment of a control system, and finally (3) the assemblage of data to form one drawing—the block diagram.

Preparation of Isometrographed Drawings of Each Level

The original plan of each mine level is printed on a sheet of paper large enough to accommodate its isometrographed tracing. This is done to keep the two maps oriented in respect to each other, to minimize the number of sheets, and to enable additional data to be added accurately, first to the original plan, and then to the drawing in perspective by use of the isometrograph.

Before operating the isometrograph, it should be adjusted to draw the angle chosen for the diagram. This angle may be 120°, and the adjustment is made in the following manner.

The stylus and copy pencil are placed in their slots so that they both lie in a line drawn perpendicular to the fixed track. An angle of 90° is then drawn so that this perpendicular line bisects it. As the sides

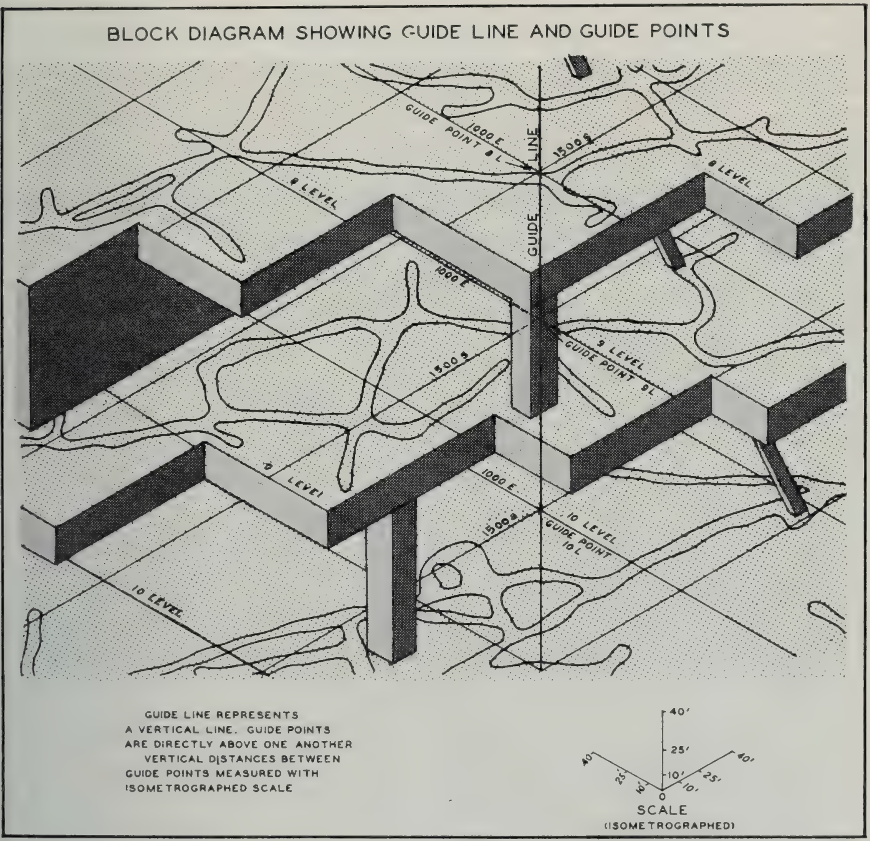
BLOCK DIAGRAM SHOWING GUIDE LINE AND GUIDE POINTS
GUIDE LINE
GUIDE POINT 8 L
1000 E
1500 S
8 LEVEL
8 LEVEL
1000 E
1500 S
9 LEVEL
GUIDE POINT 9L
9 LEVEL
1000 E
1500 S
10 LEVEL
GUIDE POINT 10 L
10 LEVEL
GUIDE LINE REPRESENTS A VERTICAL LINE. GUIDE POINTS ARE DIRECTLY ABOVE ONE ANOTHER VERTICAL DISTANCES BETWEEN GUIDE POINTS MEASURED WITH ISOMETROGRAPHED SCALE
40′
25′
10′
0
40′
25′
10′
40′
25′
10′
SCALE
(ISOMETROGRAPHED)

FIG. 5. Ideal drawing of a simple block diagram to show procedure of construction. Geology is not shown on this diagram, but the reader is referred to publications containing excellent colored block diagrams of complicated geology and ore deposits of actual mining districts, i.e. Tonopah and Grass Valley.

of the 90° angle are followed by the stylus the copy pencil of the instrument is allowed to draw the angle of the projection. If the angle is greater or less than the desired angle (120°) the stylus and copy pencil are then both moved along their slots in either direction until the correct angle is attained; but they must always lie along the line perpendicular to the fixed track. With the instrument thus properly adjusted, the delineation of the new map is in order. This is done by carefully following all lines of the original plan with a stylus and allowing the copy pencil to draw the new map in perspective.

Establishment of a Control System

All maps of the mine must tie into one coordinated control system. The coordinates of each level plan must lie directly beneath or above the other levels. A vertical *guide line* passes through corresponding guide points in each level.

In each mine-level plan the *guide point* is established. Then the *line of observation* is selected and drawn through the guide point. The level plan is oriented so that the line of observation will lie perpendicular to the fixed track of the isometrograph. When this is done, both the guide point and line of observation are transferred to the corresponding isometric tracing. The line of observation is chosen in due respect to

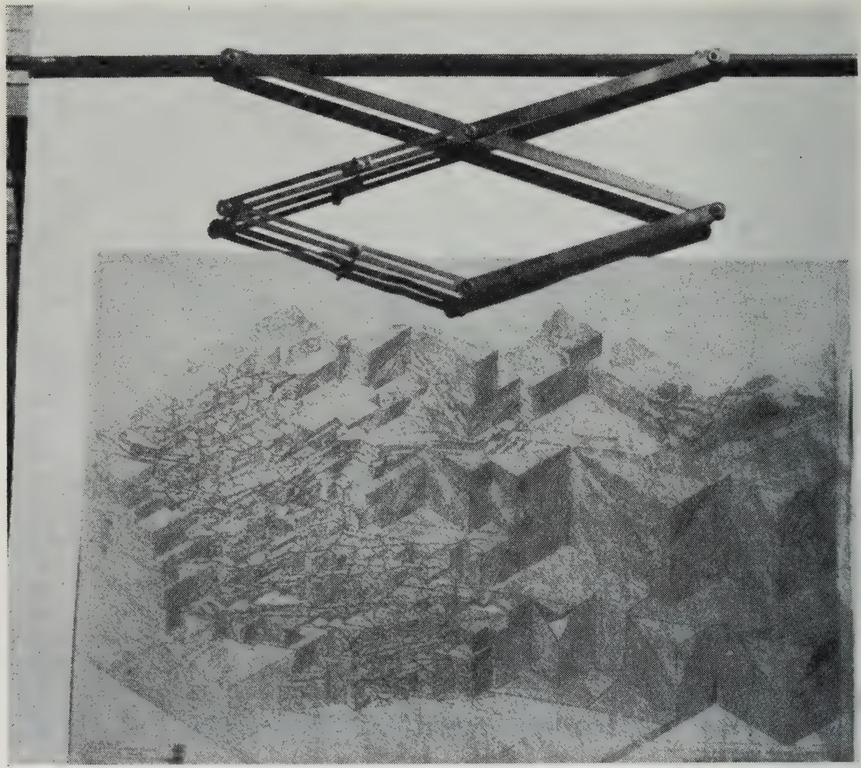

FIG. 6. Photograph of the isometrograph and the Idria block diagram made by use of this instrument.

the shape and position of the workings. In the final block diagram, a well chosen line of observation will give good visibility to the intricate workings shown in the drawing.

The horizontal scale of the isometrographed drawing and the vertical scale of the final block diagram must also be established. There are two directions, parallel to the two sides of the chosen angle along which the scale is the same. The scale is established for the new drawing by the isometrograph, by permitting it to mark off the new scale from the scale of the original plan indicated along the sides of the bisected 90° angle of that map. The vertical scale of the original block diagram should be the same as the horizontal scale of the isometrographed drawing, excepting in the case where an increase in vertical scale is necessary to permit the visibility of important features which may lie beneath an overhanging block in the final diagram.

Assemblage of Data for the Block Diagram

The final block diagram should be drawn on a sheet of paper large enough to embody data of all the separate maps. The controlling vertical guide line of the block is drawn parallel to the edge of the sheet and located in a central position so that none of the level workings will extend beyond the edge of the paper. Along the guide line should be marked to scale the interval points of each level. These represent the intersection of the levels with the guide line.

The isometrographed drawing of each level is then transferred to the block diagram. This is accomplished by simply tracing it over a glass-topped table. Orientation is done by placing the guide point and the line of observation of the isometrographed drawing directly beneath the level interval point and the guide line of the block diagram.

The next step is to draw in the blocks of the diagram which give it the perspective effect. The horizontal edges of the blocks are drawn parallel to the edges of the chosen angle, in this case 120°. The vertical edges of the block are drawn parallel to the guide line. The parts of the level which extend behind the vertical walls of these blocks must be erased while the parts of the levels which lie in front remain intact and may be inked for the final drawing. Some of the blocks are drawn so that they appear underhung or undercut. This is done so that the underlying level can be seen. Geological features, such as boundaries and formations, are drawn on the levels and continued up the walls of the blocks. Coloring of the different formations is done as on ordinary maps except that the intensity of color varies with the position on the block to bring out a shadow effect. It is assumed that the light is coming from either the upper left-hand or the upper right-hand direction. The wall in the deeper shadow must then be shaded the darkest, the other wall should be given an intermediate intensity of color or shading, and the level surface of the block should be the lightest.

If the surface topography is to be shown on the block diagram the contours are isometrographed on a separate sheet of paper from the horizontal surface map. Each contour is then traced from the isometrographed drawing on the block diagram at its proper elevation in respect to the guide line and oriented in the same manner as the orientation of the level maps.

Excellent examples of block diagrams of mines colored and shaded in the manner described may be found in the following publications:

Nolan, T. B., The underground geology of the Tonopah mining district, Nevada: Nevada Bur. Mines Bull. 24, no. 5, 1935. (In cooperation with the U. S. Geological Survey.) Plate, Block diagram of the western part of the Tonopah mining district, Nevada.

Johnson, W. D., Jr., The gold quartz veins of Grass Valley, California: U. S. Geol. Survey, Prof. Paper 194, 1940. Plate 35, Isometric block diagram of the Empire Mine and part of the Empire-Osborne Hill vein system.

DISCUSSION OF BULLETIN 118
NOTES RELATING TO SUTTER (MARYSVILLE) BUTTES GAS FIELD

By WALTER STALDER *

That through a broader statement of facts and a simple interpretation of conditions the future successful gas and oil development of Sutter Buttes, Sutter County, California, in particular, and a wider expanse of northern California in general may be benefitted, the following is written. It is directly inspired by a paper presented by Mr. Harry R. Johnson [1] which the present writer appreciates for its detail, but with which his own studies and association with this area, as with much of northern California, can not place him in full accord.

In this relation a discussion of one paragraph of Mr. Johnson's paper under *History of Development* affords opportunity to introduce pertinent facts which may also be constructively enlightening. The paragraph under consideration follows:

> "Serious efforts to develop gas and/or oil did not begin until 1932 when Mr. Walter Stalder located Buttes No. 1 and No. 2 in the NW¼ Sec. 35, T. 16 N., R. 1 E., close against the contact between deformed Cretaceous strata and an intrusive andesite plug. The results were negligible although a moderate amount of gas was obtained in one of the wells, and Buttes Oilfields Inc., which had financed the venture, transferred its activities to an area nearer the southern margin of the Buttes in T. 15 N., R. 1 E. Since June 1935, when its No. 'McPherrin' 3 was spudded, this company completed four gas wells in the area and is at present planning tests in other desirable portions of its extensive holdings."

Exploration for gas and oil at the Sutter Buttes had been in the mind of the writer for nearly 30 years before steps were taken that culminated in the discovery and development of the present gas field. The extensive holdings to which Mr. Johnson refers were delineated and acquired on the recommendation of the writer, starting in 1931. These holdings were ultimately transferred to The Buttes Oilfields Inc. which had been organized to develop them.

The Sutter Buttes structure is unique in that it is the first of its type to be tested in California, if not in the United States. The writer was particular, before development started, to outline in a paper read before the Pacific Section of the American Association of Petroleum Geologists in Los Angeles November 5, 1931, the conditions under which commercial accumulations of gas and oil might here be expected,[2] presenting for the first time such ideas in relation to this structure. Development to date at Sutter Buttes has supported the fundamental principles therein expressed. These are outlined in the following paragraphs.

In the original description of the gas and oil possibilities of the Sutter Buttes area, attention was drawn to the andesite core and later rhyolite and andesite stocks intruding the thick sediments of the Sacramento basin. These form a central igneous core surrounded by intermittent stocks and a sedimentary ring, the strata of which dip away from the igneous mass. This structure presented a gas and oil problem that appeared to have some similarities to the salt domes of the Gulf Coastal Plain and to the volcanic plugs of Mexico. Two types of possible production were anticipated. The first was in baked and cracked shales adjacent to the igneous core or beneath any sills projecting from it; under this condition it would be possible for oil to migrate along the igneous-sedimentary contact in the baked and cracked beds from depths below the reach of the drill. The second possible type of production was in lateral sands abutting the igneous core, as around salt domes.

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* Consulting Geologist, San Francisco, California. Manuscript submitted for publication August 1943.

[1] Johnson, Harry R., Marysville Buttes (Sutter Buttes) gas field: California Div. Mines Bull. 118, pp. 610-615, 1943.

[2] See Stalder, Walter, Structural and commercial oil and gas possibilities of the central valley region, California: Am. Assoc. Petroleum Geologists Bull., vol. 16, pp. 361-371, 1932.

The Buttes Oilfields Inc. well No. 1 was started in Chico (Cretaceous) sediments near the igneous core to test the first condition. Incidentally, it was located near the highest structural part of the sedimentary formations in the field, and found no water with which to contend. It was spudded October 16, 1932. It made its own mud for drilling and encountered the first show of gas at 2100 feet. This became stronger with depth. After passing through an andesite sill from 2482 to 2497 feet it entered a very brittle cracked shale body, in which it continued to 2524 feet. This shale had a very strong gasoline-like odor and caused a marked increase in volume of gas surging in the hole. From 2524 to 2727 feet, where drilling was stopped, the formation was mostly andesite.

This was the initial test for the entire field. The surging gas indicated that the well would be a producer. As it was necessary for future development that an early confidence be established in the project, the well was promptly finished and brought in February 9, 1933 with an initial maximum flow of 3,425,000 cu. ft. of gas per day and as much as 1420 pounds ''breathing'' pressure, which settled to 1275 pounds when the well had thoroughly cleaned itself. While a small well, it nevertheless demonstrated much for the field, and made history for northern California.

Here was the first high-pressure water-free gas well with a distinct petroleum odor to be brought in north of the Coalinga oil field. Its advent not only engendered the increased confidence necessary for the more extensive development which followed at Sutter Buttes, but it very effectively shattered an extremely stubborn prejudice that had persistently blocked such northern California progress for many years. It was also in the center of a large valley where supposedly well-informed oil men had predicted that only marsh gas would be found. Of far greater import, and now of extreme value to our war effort, it stimulated exploration which resulted in the discovery of a steadily increasing number of gas fields throughout this northern province. The following table, indicating such gas fields and discovery dates, was kindly furnished by Mr. E. Huguenin of the California State Division of Oil and Gas. It is pertinent with relation to The Buttes Oilfields Inc. ''Discovery'' well No. 1. This well heads the list and leads the next in line by nearly two years.

According to information transmitted to stockholders in 1936 by The Buttes Oilfields, Inc., the gas fuel furnished by its ''Discovery'' well No. 1 saved more than $30,000 in fuel bills, which was more than 60 percent of its own cost. In addition, its gas was later used for fuel toward drilling well No. 4. When last visited by the writer November 18, 1941, its gauge indicated a pressure of 690 pounds, as it stood shut-in and capable of furnishing additional gas.

Northern California high-pressure discovery gas wells

Field	*County* (Section, Township, and Range)	*Company*	*Discovery Date*
Sutter (Marysville) Buttes	Sutter 35-16N-1E M.D.	The Buttes Oilfields Inc.	Feb. 9, 1933
Chowchilla	Madera 7-10S-14E M.D.	Pure Oil Co.	Nov. 1934
Tracy	San Joaquin 15-2S-5E M.D.	Amerada Pet. Co.	Aug. 11, 1935
McDonald Island	San Joaquin 25-2N-4E M.D.	Standard Oil Co. of Cal.	June 2, 1936
Rio Vista	Solano 26-4N-2E M.D.	Amerada Pet. Co.	June 18, 1936
Fairfield Knolls	Yolo 32-9N-1W M.D.	Standard Oil Co. of Cal.	Nov. 6, 1937
Willows	Glenn 18-20N-2W M.D.	Ohio Oil Co.	Jan. 8, 1938
Tompkins Hill	Humboldt 22-3N-1E H.	The Texas Co.	Oct. 29, 1938
Vernalis	San Joaquin 25-3S-6E M.D.	Standard Oil Co. of Cal.	Jan. 8, 1940
Petaluma	Sonoma 30-5N-6W M.D.	Trico Oil and Gas Co.	Aug. 15, 1941
Lodi	San Joaquin 9-4N-7E M.D.	Amerada Pet. Co.	March 20, 1943
Mendota	Madera 16-13S-16E M.D.	The Texas Co.	April, 1943

To the present writer the facts indicate that "Discovery" well No. 1 made extremely important northern California history and, regardless of its size, it remains the discovery well for Sutter Buttes and the first high-pressure water-free "discovery" gas well for northern California.

Well No. 2 was not a true or a satisfactory test of the cracked shale area to the greater depth of 7014 feet because it used a heavy baroid mud that set like hard rubber after standing for some days, as was found when some of this material accumulated on the control valve in the cellar. The writer personally observed this well until it reached a depth of 4304 feet. Below that depth his facts are mostly from letters of The Buttes Oilfields management to its stockholders. They state that this same heavy mud was used in the lower parts of the hole, and that very strong gas and also unmistakable oil showings were encountered. There were long periods when operations were shut down. This allowed the heavy mud to seep back into the cracks and crevices and set. Regardless of the strong showings of gas in drilling, the feeders to the hole were plugged with this rubbery mud and would not produce when tested. While the results of well No. 2 were "negligible," as Mr. Johnson states, they do not disprove the area; for "Discovery" well No. 1, only 750 feet away, which was drilled with ordinary mud that did not set, is capable of production today. Before these deeper high-pressure gas and possibly oil channels are either proved or disproved, a new well will be required. In its drilling the operator may profit by the above-mentioned facts.

Wells Nos. 3, 4, 5, 6, and 7 tested and developed gas production in lateral sands on the south flank of the intrusive mass and served to demonstrate the second type of production mentioned by the writer.

With lateral sands about any structure the safest area to test is at their highest structural position. The highest part of the Sutter Buttes structure being in the neighborhood of wells Nos. 1 and 2, it is from that locality that a practical operator would start and gradually work outward and down the dip of the beds with succeeding wells until edgewater was encountered. Had a well been drilled to the south of the intrusive andesite area in the neighborhood of well No. 1, where a magnetometer survey indicated that the underlying andesite terminated, it would have been ideally located for a first test of lateral sands. As Mr. Johnson states, The Buttes Oilfields transferred its activities to an area nearer the southern margin of the Buttes where its No. "McPherrin" 3 was spudded. This well was 2 miles down-dip from No. 1. It encountered water and high-pressure gas, and its completion was postponed until well No. 4, half a mile farther up-dip toward No. 1, was brought in and completed. Although No. 3 was later brought in, it is regarded by some operators as an edge well. From his own observations, however, the writer would be reluctant to accept such a conclusion without a further check.

A magnetometer survey indicated that certain small anticlinal folds in the sedimentary rocks about the igneous core of these buttes are underlain by heavier rocks—doubtless stocks of andesite or rhyolite that do not reach the surface. Accordingly, drilling on such buckles may be treacherous.

At the present date the Shell Oil Company, which has taken over field operation on The Buttes Oilfields, Inc. lease, has brought in another well in these lateral sands up-dip half a mile closer to the core than Buttes No. 4. This new well is located approximately a mile from the structurally highest part of the sediments about Sutter Buttes in the neighborhood of well No. 1. Ultimately, drilling may return to the highest part of the structure with a new well located to test not only lateral sands, but to tap production from baked and cracked shales as well.

In the report to the Railroad Commission of the State of California and Department of Natural Resources, Division of Oil and Gas, entitled *Estimate of the Natural Gas Reserves of the State of California as of January 1, 1941,* Dr. John F. Dodge bases his calculations of gas reserves at Sutter Buttes on a "fault block" as mapped by Mr. Johnson and limited to an area of 6,680 acres (page 240). Therein the basic fact is overlooked that the most important fault of the entire area is at the contact of the central igneous plug with the surrounding sedimentary ring. Any other fault on the down-dip side would necessarily have to extend in a circle around the entire intrusion to trap all gas or oil rising to the core. As no such circular fault exists, the central core will always be the main barrier to which the bulk of the gas or oil will migrate and against which it will concentrate. Also, according to structure as analyzed by the writer, the fault mapped by Mr. Johnson has been caused by a hidden intrusion from the side of the plug below the surface, and the fault hades into the central plug. Deeper hidden intrusions of the same type will cause deeper faults with the hade always into the central plug. The acreage used in the estimate of Dr. Dodge is, therefore, seemingly too small.

Structurally, the Sutter Buttes are so high with relation to the surrounding Sacramento Valley, and the feeding area to them for oil and gas is so large from beneath that valley, that they constitute an ideal locality to test to great depths for other gas and possibly oil horizons. It is the central core of these buttes that forms the barrier against which such gas and oil will accumulate. Since well No. 3 has produced gas 2 miles down-dip from that core, an area of nearly 20,000 acres in the sediments surrounding the central igneous mass is subject to future exploration for the purpose of accurately determining the limits of the field for accumulation in lateral sands.

SPECIAL ARTICLES

THE SILLIMANITE GROUP OF MINERALS

By JOSEPH A. JEFFERY *

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PROPERTIES

The three minerals andalusite, sillimanite, and kyanite, are aluminum silicates having the chemical formula $Al_2O_3 . SiO_2$. Although they are identical in composition, with 63.2 percent of alumina and 36.8 percent of silica, they differ in crystallization. Together with dumortierite they constitute what is known as the sillimanite group of minerals. Dumortierite is a basic aluminum borosilicate with the approximate formula $8Al_2O_3 . 6SiO_2 . B_2O_3 . H_2O$. Although it contains some fluxes and more alumina than the foregoing three minerals, it resembles them in thermal behavior and has a similar practical application. These four minerals, when heated to high temperatures, form the crystalline compound mullite, $3Al_2O_3 . 2SiO_2$, the crystallographic and optical properties of which are very similar to those of sillimanite.

Andalusite, sillimanite, dumortierite, and mullite are orthorhombic in crystallization, whereas kyanite crystallizes in the triclinic system. The crystal habit of mullite and sillimanite is that of acicular prismatic crystals or needles. Kyanite occurs in long-bladed crystals or coarsely bladed masses. Andalusite forms elongated crystals or columnar masses. The variety known as chiastolite or macle is characterized by stout prismatic crystals having inclusions of carbonaceous impurities systematically arranged to form black crosses. Dumortierite occurs as fibrous, columnar, and matted masses.

The hardness of each of these minerals, except kyanite, is between 6 and 7.5. Although its hardness across the crystal is 7, kyanite has a hardness of only 4.5 parallel to the crystal length. The specific gravity of the minerals ranges from 3.1 to 3.6. The luster is vitreous to pearly. All exhibit good to perfect cleavage parallel to the length of the crystal.

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In kyanite imperfect cleavage may also be observed at almost a right angle to the more prominent cleavage. The color varies in general as follows: sillimanite—white, gray, brown, green, and shades of these; andalusite—gray, pink, brown, green, and shades of these; kyanite—blue, gray, white, green, brown, or black; dumortierite—usually violet or smalt blue but may be lavender, pink, purple, lilac, green, white, or colorless.

For detailed descriptions of individual minerals, consult references (3), (8), (9), and (10).

TESTS

Small fragments of andalusite, kyanite, sillimanite, and dumortierite turn blue when intensely heated on charcoal, moistened with cobalt nitrate solution, and again ignited. This is the standard test for infusible aluminum minerals. An excellent method for detecting the boron in dumortierite is to mix some of the powdered mineral with boron flux (one part powdered fluorite to two parts potassium bisulphate). Slightly moisten the mixture, pick up a little in the loop of a platinum wire, and hold it in the blowpipe flame. Just at the moment of fusion a green color appears, then disappears almost immediately. A colored screen which eliminates yellow light, such as the Merwin screen, aids in viewing the green color.

Andalusite may usually be distinguished by its prismatic crystals of nearly square cross-section. Kyanite may be recognized by its bladed form, blue color, and hardness varying with direction. Sillimanite is characterized by its fibrous columnar form. Dumortierite often resembles tourmaline, and optical tests may be necessary to distinguish it. The fibrous habit is generally characteristic, but in the bulk of the Nevada deposits fibers are indistinguishable, and the mineral occurs as matted masses with a pronounced schistose structure.

OCCURRENCE

The minerals of the sillimanite group are long-recognized and well known minerals. They have been brought into prominence since 1918 by the discovery, in the field of ceramics, of uses to which they are well adapted. The word ''kyanite'' (sometimes written ''cyanite'') was derived from the Greek word meaning blue. This mineral was first described by deSaussure in 1785. Andalusite was first found and identified in 1789 in Andalusia, Spain, whence its name. Sillimanite, named for Professor Benjamin Silliman of Yale University (1779-1864), according to Dana was first reported in 1792 under the name ''fibrolite.'' Dumortierite seems first to have been found by Ferdinand Gonnard in 1879 and named by him in honor of Eugene Dumortier, the eminent French paleontologist. Mullite was originally noted in artificial melts and porcelains, but was long mistakenly believed to be sillimanite. In 1924 Bowen and Greig showed that in artificial melts containing Al_2O_3 and SiO_2 in varying proportions, the compound $3Al_2O_3 . 2SiO_2$ is formed. They named this compound mullite, because of the discovery on the Island of Mull of the rare natural mineral of similar composition. There it occurs in buchites, fused argillaceous sediments occurring as inclusions in Tertiary lavas. For a more detailed discussion of occurrences of these minerals than appears below, see references (5), (7), (8), (9), (10), (11), and (18).

Kyanite

Kyanite is the most widespread and abundant of the sillimanite group of minerals. Although it is not a common rock-forming mineral, it is found in many localities throughout the world. It occurs as disseminated crystals in gneiss or schist, as lenses in pegmatite dikes, irregularly distributed through quartz veins and quartzite masses, and in residual clay formed by the weathering of kyanite gneiss. One of the most frequently associated minerals is quartz, and it is often accompanied by feldspar, biotite, garnet, muscovite, pyrite, tourmaline, corundum, and staurolite. Kyanite is thought to have been formed under conditions of great pressure and high temperature during the recrystallization of rocks by metamorphic processes. The color, crystalline structure, relative abundance, and associated minerals of kyanite vary widely in different localities. Although found in many places, it occurs in commercial quantity in only a few. The most important economic occurrences are the deposits of disseminated crystals in gneisses and schists. In the United States, kyanite occurs in many places in the belt of crystalline rocks along the Atlantic seaboard. Deposits of economic value occur in North Carolina, Virginia, and Georgia. In California it is being mined from a deposit 10 to 200 feet wide in mica schist at the base of Chocolate Mountain near Ogilby, in Imperial County. In Tuolumne County it is found as a constituent of schists on Yankee Hill.

Andalusite

Andalusite is most common as a contact mineral in clay-slates and argillaceous schists, especially in connection with granitic intrusions. It occurs also in gneisses, phyllites, and granite pegmatites. Among the minerals which are associated with andalusite are tourmaline, corundum, topaz, garnet, pyrophyllite, diaspore, quartz, biotite, muscovite, lazulite, barite, alunite, and rutile. Andalusite-bearing rocks crop out in many places throughout the world, but the occurrence at White Mountain, California, is the only known deposit in which andalusite is present in sufficient quantity to be of commercial value. This important occurrence was discovered in 1919 by Dr. Joseph A. Jeffery, President of Champion Sillimanite, Inc., Laws, Inyo County, California. The deposit is located at an altitude of 9,000 feet in a zone roughly 2 miles long and 30 feet wide. The andalusite occurs as irregular segregations in a great lenticular quartz mass, bordered on each side by sericite schist free from andalusite. Much of the quartz contains andalusite, but only limited areas are rich enough to be worked. All of the mineral associates noted in foregoing paragraphs as occurring with andalusite are present in this deposit. They are either beneficial in the manufacture of porcelain or occur in only negligible amounts. Rutile comprises 2 or 3 percent of the ''ore.'' The ''ore'' itself is bluish-gray in color, which may be due to the presence of titanium in solid solution.

Sillimanite

Sillimanite is the most stable mineral of the group, and appears to be the most scarce. It occurs in gneisses, schists, slates, and hornfels, and is probably produced at higher temperatures in nature than are the other minerals of the group, but under essentially similar conditions of metamorphism. It is found in separate crystals or in aggregations of slender minute prisms in parallel or radiating arrangement. It is often accompanied by quartz, muscovite, garnet, cordierite, corundum, and andalusite. Sillimanite has been observed in many localities throughout the world. In eastern United States, it occurs in a number of places, but the impure character of the material and the frequent intimate association with quartz largely prevent commercial development. In California sillimanite has been reported as occurring in schists in Inyo, Los Angeles, Mariposa, and San Bernardino Counties, and as a constituent of dumortierite gneiss in San Diego County. It has also been noted in Tuolumne County. There has been no commercial development in the State, however, as the known deposits are too small to be of value.

Dumortierite

Dumortierite is commonly found as fibrous acicular and radiating or fan-like inclusions in other minerals, chiefly in quartz, muscovite, feldspar, and cordierite. Occasionally it occurs as large masses, but even in such cases much of it is included in quartz and muscovite. Usually some other aluminum-bearing mineral is present, such as andalusite, kyanite, corundum, pyrophyllite, sillimanite, or topaz. Quartz is almost invariably present and the common boron-bearing associate is tourmaline. Many other minerals are associated with dumortierite, but occur in very small amounts as inclusions or alteration products. Although dumortierite is a rare mineral, and of less common occurrence than andalusite, kyanite, and sillimanite, it has been found practically the world over, associated with granites, pegmatite dikes, high-temperature quartz veins, and contact-metamorphic deposits. The only deposit of a commercially suitable character and extent thus far discovered, is that owned and operated by Champion Sillimanite, Inc. located near Oreana, Nevada. In this deposit the mineralization is concentrated along two parallel zones in a quartz-sericite schist in which there are irregular lenses of andalusite partially or entirely altered to dumortierite. The schists were originally rhyolitic tuffs, but they have been invaded and metamorphosed by a granitic intrusive. Quartz-dumortierite veins were formed at a later period than the lenticular masses, but these veins are economically worthless. Many shades of pink, an unusual color for dumortierite, are common in this deposit. In massive character, size, and association with mica schist, this deposit is similar to that of andalusite at White Mountain, California. Dumortierite is found in seven states in the Union. In California it occurs in Imperial County in boulders over a wide area about 10 miles northwest of Ogilby. In Riverside County, massive dark-blue dumortierite is found in the Pinacate district. It is also reported to occur in quartz monzonite near Corona, and in granodiorite 13 miles southwest of Riverside. In San Diego County, violet-red dumortierite is found near Dehesa. As yet there has been no commercial development in the State.

PREPARATION

The minerals of the sillimanite group are rarely free from mineral associates. Some of these are not a detriment to the ''ore'' if present in small amounts, but quartz must be kept as low as possible, and pyrite, magnetite, and limonite if present in more than traces, must be removed. The most convenient commercial test for grade is specific gravity. For this purpose either the Kraus Jolly Balance or the Spencer direct-reading specific gravity balance may be used. Commercial andalusite, for example, should have a specific gravity of at least 3.00 to be considered high-grade. The andalusite of Champion Sillimanite, Inc. at White Mountain, California, requires selective mining and hand sorting. The "ore" is mined from large chambers and stopes connected by a series of tunnels. On the whole, the rock material is high in andalusite, its specific gravity averaging between 3.01 and 3.06. The apparent specific gravity of the "ore" varies directly with the silica and alumina content; for this reason the "ore" is mined and blended according to specific gravity determinations made at the mine at frequent intervals. Samples are taken over the face of the working, and manual breaking is used, as far as possible, in order to eliminate quartz and pyrite. The sorted ore is put in piles of about 5 tons each and an average sample, consisting of ½-inch pieces, is taken for the specific gravity determinations. Generally microscopic examination shows that the "ore" runs at least 75 to 85 percent andalusite. "Ore" passing the required tests is sacked in 95-pound sacks and packed on mules 4 miles to a point whence it is trucked 3 miles to a railroad. Here it is put in stockpiles of 2,000 tons each, arranged in long, parallel, adjoining rows. For uniform grade, the material is withdrawn at right angles to the original spreading direction. Dumortierite is mined and handled in a similar manner by the same company.

At the plant of the Champion Spark Plug Company, Ceramic Division, Detroit, Michigan, the "ore" is crushed and ground, passed over a magnetic separator, and screened into three sizes: 8 to 14 mesh, 14 to 30 mesh, and 30 mesh and finer. These three sizes are used in equal proportions in refractories. In making porcelain and bodies of similar type, fine grinding is essential. The andalusite is compounded with other body ingredients, such as the fluxes and clays, mixed with water and reground to pass 325 mesh. It is then lawned, passed over a magnetic separator, and freed of excess water in a filter press. In this way the plastic body (or slip) can be handled and stored in an aging cellar for use in forming ceramic products. The ground slip is spray dried for processing by special patented methods. Spark-plug insulators are fired in continuous kilns 300 feet long at 2,700° F., three days being required for passage through the kiln. The andalusite "ore" is of particular value because it has no appreciable volume change when converted to mullite. It may, therefore, be used without previous calcination. Dumortierite from the Oreana, Nevada, deposit of Champion Sillimanite, Inc., is shipped to Detroit and treated in the same way as is the finely ground andalusite. It fires to a pure white color and the fluxes, particularly boron, have a beneficial effect upon the properties of the spark plug insulators. The addition of dumortierite also improves or widens the firing range of the bodies.

Kyanite in the deposits of North Carolina, Georgia, and Virginia is associated with much quartz, and the "ore" must be concentrated. The McLanahan-Watkins Company, of Charlotte Courthouse, Virginia, uses a simple wet gravity process of concentration. The "ore" occurs in a decomposed rock and residual clay 40 to 50 feet deep overlying the hard, fresh, kyanite-bearing quartzite. Celo Mines, Inc., Burnsville, North Carolina, use a dry process in which the ore is crushed to ¾-inch size and then ground in a rod mill in closed circuit with a vibrating screen. The associated minerals, garnet, staurolite, quartz, feldspar, and biotite, are then separated by means of an induction magnetic separator and an electrostatic separator. The material is prepared in various degrees of concentration up to 98 percent kyanite, with a very low iron content. Calcined kyanite is likely to be friable and difficult to bond. Calcination is necessary before using it in any great percentage because of the great expansion which takes place on firing to high temperatures. Upon heating kyanite to about 2390° F. to 2465° F., the original specific gravity (3.6) drops to that of a mixture of mullite and cristobalite or silica-glass (3.1). One industrial application of kyanite takes advantage of the fact that small needle-like grains swell slightly and elongate considerably on conversion. If incorporated in a ceramic body prior to elongation, they elongate during firing and increase the mechanical strength of the body. The best results are obtained when crystals are heated to just below the conversion point and then incorporated. This treatment and the removal of excess quartz are accomplished in one operation by the Vitrefrax Corporation, Los Angeles, California. The ore is first calcined in a rotary kiln in which the iron oxide is reduced so it can be removed with a magnetic separator. The hot calcine, heated in kilns to expand the quartz, is rapidly chilled in water to contract the quartz. The rapid contraction converts the quartz to a very fine sand which is readily separated from the coarse kyanite calcine by slightly inclined shaking screens.

According to an article which appeared in the Engineering and Mining Journal issue of February 1942, Kyanite Products Corporation, an associate of the Phosphate Recovery Corporation, 61 Broadway, New York, is regularly mining and refining kyanite in Virginia, and during 1941 produced at the rate of 450 tons a month.

Each mineral of the sillimanite group is converted to mullite if fired high enough. Conversion of andalusite takes place in practice at about 1350° C. (2462° F.). Kyanite shows signs of conversion as low as 1100° C. (2012° F.), but 1350° C. (2462° F.) is usually given as the temperature of marked conversion. The conversion of sillimanite begins at 1545° C. (2813° F.), but a somewhat higher temperature, e.g., 1600° C. or 2912° F., is probably necessary in practice. Dumortierite is the most readily converted of the group, conversion taking place in the neighborhood of 1200° C. (2192° F.). For more detailed discussion of the thermal behavior of these minerals, consult references (4), (11), (15), and (18).

USES

Many ceramic uses have been found for minerals of the sillimanite group. The most important use of andalusite is in the manufacture of insulators for spark plugs. It has also been used for laboratory ware, and proves to be heat-resistant. Mullite, made from a mixture of electrically fused diaspore and clay, and cast into shape in sand molds, is used extensively in the manufacture of blocks for furnaces in which glass is melted. Some andalusite and considerable kyanite are also used in the manufacture of glass-house refractories that are fabricated in the usual manner. Ramming mixes or plastic patching material for metallurgical processes are made from andalusite or kyanite or from other mullite materials. These are thoroughly mixed with a binder and a definite amount of water, then shipped in sealed containers to preserve the original physical condition. Dumortierite is used in the same manner as is andalusite.

The cost of the raw material is the limiting factor in a more widespread use of the minerals of this group. The high cost may be offset by the large-scale, low-cost production from some large bodies of kyanite rock in some of the southern Appalachian states.

MARKETING

The Champion Spark Plug Company markets andalusite refractories as ''Champion Sillimanite,'' and the spark plug insulators bear the trade name ''Champion.'' Refractory products of the Vitrefrax Corporation are sold under the trade name ''Argon'' and ''Durex.'' Kyanite and mullite produced by the Celo Mines, Inc. are made into refractories and refractory cements. The 1940 record high domestic kyanite production was nearly doubled in 1941. In the latter year production reached 8,335 tons, valued at $175,581, yielding an average value of $21 a ton.

POSSIBLE BUYERS

Commercial deposits of the aluminum silicate minerals are largely in the hands of private companies which are also manufacturers. Some possible buyers are given in the following list:

California:

Vitrefrax Corporation, Los Angeles
The Refractories Corporation, Los Angeles

Connecticut:

Mullite Refractories Company, Shelton
Hartford-Empire Company, Hartford

Colorado:

Coors Porcelain Company, Golden
Denver Fire Clay Company, Denver

Missouri:

A. F. Green Fire Brick Company, Mexico
Laclede-Christy Clay Products Company, St. Louis

Ohio:

The Charles Taylor Sons Company, Cincinnati

Pennsylvania:

General Refractories Company, Philadelphia

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NEW FEDERAL AND STATE LEGISLATION AFFECTING MINING

ASSESSMENT WORK ON MINING CLAIMS SUSPENDED FOR THE DURATION

Congress has again passed a moratorium act suspending assessment work on mining claims for the duration of the war. The text of the act which was approved by the President May 3, 1943, follows.

Public Law 47—78th Congress. H. R. 2370.

Chapter 91—1st Session.

An Act providing for the suspension of annual assessment work on mining claims held by location in the United States, including the Territory of Alaska.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provision of Section 2324 of the Revised Statutes of the United States, which requires on each mining claim located, and until a patent has been issued therefor, not less than $100 worth of labor to be performed or improvements aggregating such amount to be made each year, be, and the same is hereby, suspended as to *all* mining claims in the United States, including the Territory of Alaska, until the hour of 12 o'clock meridian on the first day of July after the cessation of hostilities in the present war as determined by proclamation of the President or concurrent resolution of the Congress: *Provided,* That every claimant of any such mining claim, in order to obtain the benefits of this act, shall file, or cause to be filed, in the office where the location notice or certificate is recorded, on or before 12 o'clock meridian of July 1st for each year that this act remains in effect, a notice of his desire to hold said mining claim under this act.

[Approved May 3, 1943.]

SENATE BILL No. 291

CHAPTER 207

An act, relating to the relief of gold and silver mining operators, permitting postponement of sales under certain chattel mortgages, mortgages, deeds of trust or contracts of purchase on gold and silver mines and gold and silver mining machinery and equipment, or postponement of forfeitures and terminations under gold and silver mining contracts and leases, regulating appointment of receivers in certain cases, extending the time in which the purchase price may be paid and extending the statute of limitations, declaring the urgency thereof, to take effect immediately.

[Approved by Governor April 24, 1943. Filed with Secretary of State April 24, 1943.]

The people of the State of California do enact as follows:

SECTION 1. Due to the necessity of conserving labor and strategic materials in connection with the war effort, the United States War Production Board has issued an order directing the cessation of operations of gold mines throughout the United States. The issuance of this order has caused widespread distress among the gold miners of California, and the Legislature finds that as a war measure it is necessary to provide for the relief of said distress in the following manner until causes of said distress have been removed by cessation of the war.

This act shall, therefore, be effective until six months after the termination of hostilities between the United States and all nations with which the United States is at war as determined by an act of Congress or proclamation of the President of the United States, or until October 1, 1945, whichever first occurs.

SEC. 2. Any person who is or has been engaged in mining gold or silver from any mining property of which property he is the owner and which property produces no revenue except from the mining of gold and silver, and against which property he has incurred obligations in connection with its purchase, or which he holds under contract (1) providing for his purchase or lease of such property or giving him an option to purchase or lease such property, or an interest therein, or stock in a corporation which holds title thereto, and (2) requiring the performance of certain work on such property, or on adjacent property or properties or periodic rental or installment payments with respect thereto, or minimum royalties, or (3) holds the property subject to a mortgage or trust deed or (4) holds gold or silver mining machinery or equipment under contract of sale or subject to chattel mortgage, and who has been prevented by reason of any statute, rule, regulation, or order of the United States, or of any officer or agency of the United States made in connection with the National defense or war effort from (1) obtaining necessary supplies or equipment with which to perform the minimum work requirements of his contract, or (2) from obtaining or employing the necessary workmen to carry out the terms of his contract, or (3) as a result of said prevention, from producing ore or gold-bearing gravel from the proceeds of which payments on said obligations could be made, or payment could be made on the purchase, lease or option to purchase of other mining property in California or stock in a corporation which holds title thereto, which the person is purchasing or leasing for the purpose of fulfilling his program of mining operations, shall be entitled, upon establishing these facts, to the satisfaction of any superior court having jurisdiction in the premises, to receive a moratorium order suspending his obligations under said contract under which he holds the property, or an interest therein, or the right to acquire stock in any corporation holding the title thereto as aforesaid, during the effective period of such statute, rule, regulation, or order, and for a period of six months after the termination of said effective period. In considering whether or not such petitioner is entitled to receive a moratorium order the court to whom the petition is addressed may consider the issuance of any such regulation, rule or order pursuant to the terms of a statute of the United States as conclusive evidence of the prevention of the petitioner from performing his contract by causes wholly beyond his control, if the court finds that such regulation, rule or order has prevented said petitioner from carrying on operations on said property or producing gold or silver therefrom.

Sec. 3. The court, in its discretion, if it finds that the ability of such person to produce gold and silver sufficient in quantity to enable him to make the payments required under such contract from the proceeds of his operation or otherwise to perform the terms of his contract has been impaired by reason of said order, rule or regulation, (a) may make an order suspending, in whole or in part, the requirement that such work be performed or such payments be made; and (b) may make such other disposition of the case as may be equitable to conserve the interests of all parties, including an extension of the term of any contract or lease for a period corresponding to the period during which such war order, rule or regulation remains in effect; provided, however, that in no case shall such suspension under (a) extend for more than six months after the termination of the present war.

Sec. 4. The relief made possible under this act shall also extend to a person who is or has been engaged in mining gold or silver from any mining property, and has been prevented from continuing operations for any of the reasons mentioned in Section 2 hereof with respect (1) to the payment of the balance of the purchase price of any equipment which may have been purchased on a conditional sales contract and placed on the premises prior to the effective date of said order, rule, or regulation preventing continued operation; and (2) to the enforcement of any mortgage, attachment, or other lien against said premises or against the mining property covered by said prevented operation for nonpayment of any debt, or for nonpayment of taxes accruing after the effective date of said preventing order, rule or regulation.

Sec. 5. Subject to the limitations as to time provided in Section 1 hereof, any operator of gold or silver mining property who has ceased operating pursuant to the restrictions imposed on gold or silver mining by the United States, and who is in danger of forfeiture under any of the instruments named in Section 2 hereof, may file a petition in the superior court of the county in which such gold or silver mining property or machinery or equipment or the major portion thereof is situated, praying for an order postponing the sale of such property or machinery and equipment, or prevention of forfeiture under the instruments set forth in Section 2 hereof.

SEC. 6. A copy of such petition shall be served upon the trustee and the beneficiary under such deed of trust, upon the mortgagee under such mortgage, upon the lessor in a lease providing for payment of minimum royalties and upon the holder of the contract of sale or chattel mortgage on machinery and equipment or the obligee in any contract mentioned in Section 2 hereof, as the case may be, in the manner provided by law for the service of summons in a civil action.

A notice of pendency of such petition shall immediately be recorded in each county in which any of such property is situated, and on the day of such recordation a copy thereof shall be mailed, postage prepaid, from a post office within this State, addressed to such trustee and beneficiary, such mortgagee, or the holder of the contract of sale or chattel mortgage on machinery and equipment, or upon the lessor in a lease providing for payment of minimum royalties or the obligee in any contract mentioned in Section 2 hereof, as the case may be, at their respective places of residence, if known to petitioner, if not, then at the county seat of the county, or at the city and county, where the proceeding is pending.

Such notice of pendency shall state the name of the petitioner, the nature of the petition, and the book and page of the records of the county recorder in which the mortgage or deed of trust or other instrument is recorded.

SEC. 7. Upon application of the petitioner, after service of such petition, or upon application of any other interested party after the filing of the petition, a hearing shall be had thereon within 20 days after such application, upon such notice as the court shall reasonably prescribe; provided, however, that the court if it finds equitable grounds therefor, may postpone such hearing for not to exceed 10 days.

After the filing of such petition and the recording and mailing of the notice of the pendency thereof as provided in Sections 5 and 6 of this act, no sale under the power of sale conferred by such deed of trust or such mortgage or other instrument shall be held nor shall any forfeiture be effected under any of the instruments set forth in Section 2 hereof until the court makes its order in the matter, but nothing herein contained shall prevent such sale or forfeiture at any time after October 1, 1945, or six months after termination of the war, whichever shall first occur.

SEC. 8. Upon such hearing the court may make its order, if it finds equitable grounds for relief, and finds that the security will not be unreasonably jeopardized thereby, ordering that such sale shall not be held or forfeiture declared until after such date as the court considers just and equitable, but in no event shall such date be beyond October 1, 1945, or six months after termination of the war, whichever first occurs, or may make its order dismissing such proceedings.

If the court orders the sale or forfeiture postponed it shall determine the reasonable value of the income from such property, or if the property has no income, then the reasonable rental value of such property, or if the property is unimproved, a reasonable sum to be paid by the trustor or mortgagor, or holder under other instrument set forth in Section 2 hereof, as determined by the court, and by such order shall require the trustor or mortgagor to pay all or at least a reasonable part of such income, rental value, or sum so determined by the court, in or toward the payment of taxes, insurance, interest, or principal of the indebtedness at such times and in such manner as are determined to be just and equitable under the circumstances.

SEC. 9. The court must include in such order provisions requiring maintenance and repair by the trustor or mortgagor, or holder under other instrument set forth in Section 2 hereof, regulating the disposition of any income from the property and such other provisions as it deems just and equitable for the protection of the security, but in no event shall the court order the payment by the trustor or mortgagor or holder under other instrument set forth in Section 2 hereof of a lesser sum than necessary to pay (a) current taxes, (b) all delinquent taxes, except that such taxes may be paid in installments as may be provided by law, and (c) any insurance premiums required to be paid by the petitioner under the contract between the parties.

SEC. 10. When any mortgage or deed of trust upon property, or upon machinery and equipment attached to or used in operating gold or silver mining property or other instrument, has been foreclosed, and the property covered thereby has been sold in whole or in part under decree of foreclosure, and the period of redemption has not yet expired, the mortgagor or trustor thereof, or holder under other instrument set forth in Section 2 hereof, having the right of redemption, may at any time not later than October 1, 1945, or six months after termination of the war, whichever first occurs, file a petition in the superior court of the county in which the property so sold or the major portion thereof is situated, praying for an order extending such period of redemption.

SEC. 11. A copy of such petition shall be served upon the purchaser of such property at the foreclosure sale, or, if there has been a redemption, upon the last redemptioner, in the manner provided by law for the service of summons in a civil action.

A notice of pendency of such petition shall immediately be recorded in each county in which any of such property is situated, and, on the day of such recordation, a copy thereof shall be mailed, postage prepaid, from a post office within this State, addressed to such purchaser or last redemptioner, as the case may be, at his place of residence, if known to petitioner, if not, then at the county seat of the county, or at the city and county, where the proceeding is pending.

Such notice of pendency shall state the name of the petitioner, the nature of the petition, and the book and page of the records of the county recorder in which the mortgage or deed of trust or other instrument is recorded.

SEC. 12. Upon application of the petitioner after service of such petition, or upon application of any other interested party, after the filing of the petition, a hearing shall be had thereon within 20 days after such application, upon such notice as the court shall reasonably prescribe; provided, however, that the court, if it finds equitable grounds therefor, may postpone such hearing for not to exceed 10 days.

Upon the filing of such petition and the recording and mailing of the notice of pendency thereof as provided in Sections 10 and 11 of this act, the period of redemption, if such period would sooner terminate, shall be extended until 10 days after the court makes its order in the matter, but in no event beyond October 1, 1945, or six months after termination of the war, whichever first occurs.

SEC. 13. Upon such hearing the court may make its order, if it finds equitable grounds for relief and finds that the security will not be unreasonably jeopardized thereby, extending such period of redemption for such additional time as the court considers just and equitable, but in no event beyond October 1, 1945, or six months after termination of the war, whichever first occurs, or may make its order dismissing such proceeding.

If the court by its order extends the period of redemption, it shall determine the reasonable value of the income from such property, or if the property has no income, then the reasonable rental value of such property, or if the property is unimproved, a reasonable sum to be paid by the operator as determined by the court.

The court shall require the operator to pay all or at least a reasonable part of such income, rental value, or sum so determined by the court, in or toward the payment of taxes upon such property, the cost of insurance and the sums to which the purchaser of such property at such foreclosure sale, or the last redemptioner, as the case may be, is entitled under the provisions of Section 707 of the Code of Civil Procedure, at such times and in such manner determined to be just and equitable under the circumstances.

Sec. 14. The court may include in such order provisions requiring maintenance and repair by the operator, regulating the disposition of any income from the property, and such other provisions as it deems just and equitable for the protection of the interest and security of the purchaser or last redemptioner, as the case may be.

In no event shall the court order the payment by the operator of a lesser sum than the greater of (1) the amount of such reasonable value of the income, or such reasonable rental value, or such reasonable sum so determined by the court, or (2) a sum sufficient to pay (a) current taxes, (b) all delinquent taxes, except that such taxes may be paid in installment as provided by law, and (c) a sum reasonably necessary for fire and other insurance upon any improvement upon such property.

Sec. 15. Any sums paid to a purchaser or redemptioner pursuant to Sections 13 or 14 of this act shall be a credit upon the redemption money to be paid as provided in Section 707 of the Code of Civil Procedure; but in the event no redemption is made, the same shall belong to such purchaser or redemptioner.

Sec. 16. Nothing in this act shall be construed as abridging or limiting the statutory right of redemption provided in Sections 701, 702, 703, 704, 705, 706 and 707 of the Code of Civil Procedure, or as shortening the period of redemption as therein provided, or as altering the mode or procedure for redemption as therein provided.

Sec. 17. In any decree rendered prior to October 1, 1945, foreclosing a mortgage or deed of trust upon real property, the court may provide that the sale of the property shall not be held until on or after such date as the court considers just and equitable, but in no event later than October 1, 1945. If the court provides in such decree that the sale shall not be held until on or after such date as it shall fix, it shall determine the reasonable value of the income from such property, or if the property has no income, then the reasonable rental value of such property, or if the property is unimproved, a reasonable sum to be paid by the trustor or mortgagor or holder under other instrument set forth in Section 2 hereof, as determined by the court, and shall require the trustor or mortgagor or holder under other instrument set forth in Section 2 hereof to pay all or at least a reasonable part of such income, rental value, or sum so determined by the court, in or toward the payment of taxes, insurance, interest, or principal of the indebtedness at such times and in such manner determined to be just and equitable under the circumstances. The court may include in such order provisions requiring maintenance and repair regulating the disposition of any income from the property, and such other provisions as it deems just and equitable for the protection of the security.

After such hearing the court, if it shall determine that it is equitable and just so to do and that the security will not be unreasonably jeopardized thereby, may make its order postponing to a date not later than October 1, 1945, or six months after termination of the war, whichever shall first occur, the foreclosure, termination or forfeiture of the petitioners' interest under such contract of purchase on substantially the same terms and conditions as those prescribed in Sections 5, 6, 7, 8 and 9 of this act, or the court may make its order dismissing such proceeding.

Sec. 18. If the trustor, mortgagor or purchaser under a contract of purchase commits waste or defaults in any payment or act required by order or decree of court, the court, unless good excuse therefor is shown, shall order that the sale, foreclosure, termination or forfeiture postponed by its order or decree proceed as provided by law, or that the period of redemption extended by its order or decree shall expire on the making of its order or within the time provided by law, whichever shall last occur, and that the moneys to be paid on redemption, if theretofore reduced, be increased to the extent of such previous reduction, if it finds after hearing upon such notice to the original petitioner or his attorney as it prescribes, that there has been such waste or such default, unless good excuse therefor is shown, amounting to a material breach of the order or decree of postponement or extension.

Sec. 19. No suit or action shall be commenced against the guarantor of any note secured by a mortgage or deed of trust upon gold or silver mining property, or upon chattels attached to or used in connection with gold or silver mining property, in any case while, pursuant to the provisions of this act, no sale may be made under any power of sale contained in such mortgage or deed of trust or while no sale may be made under the final decree of foreclosure rendered in an action to foreclose such mortgage.

Sec. 20. No sale shall be made under any decree of foreclosure, of, or under any power of sale contained in, any chattel mortgage upon any personal property located in and used in connection with the operation of any building located upon gold or silver mining property, until on or after such date as a sale of such gold or silver mining property is lawfully held under such mortgage, deed of trust, or contract of purchase, when such chattel mortgage was given as additional security for an obligation also secured by deed of trust, mortgage, or contract of purchase, on such real property or other instrument mentioned in Section 2 hereof.

Sec. 21. Whenever the time within which an action may be commenced upon any obligation founded upon a written instrument secured by chattel mortgage, mortgage, deed of trust or contract of purchase, or founded upon any guarantee of such obligation or any contract of suretyship therefor or any endorsement of such instrument, would expire by virtue of Section 337 of the Code of Civil Procedure, or any other provision of law, during the period commencing with the effective date of this act and ending on the date upon which this act shall cease to be in effect, with respect to any property or chattel relating to which a petition has been filed under this act, such time is hereby extended so as not to expire until December 31, 1945, or nine months after cessation of the war, whichever shall first occur.

SEC. 22. Nothing contained in this act shall apply to or be deemed to affect:

(a) Any mortgage, deed of trust, lease agreement, operating agreement or contract of sale upon gold or silver mining property, or upon chattels attached to real property, executed after the effective date of this act.

(b) Any mortgage or deed of trust while held and owned by the original lender securing any loan made by the United States Government or any agency thereof or any loan insured by the United States Government or any agency thereof; and any judgment entered in favor of, or any sheriff's or commissioner's certificate of sale issued to the United States Government or any agency thereof in an action to foreclose any such mortgage or deed of trust;

(c) Any mortgage or deed of trust securing an obligation in default at the time the owner or owners acquired title by purchase subsequent to the effective date of this act.

SEC. 23. As used in this act:

(a) The terms ''mortgagor,'' ''mortgagee,'' ''trustor,'' ''trustee,'' ''purchaser,'' ''vendor,'' ''lessee,'' and ''guarantor,'' shall include their personal representatives, assigns or successors in interest, and the singular shall include the plural.

(b) The term ''trustee'' shall also include the beneficiary of a deed of trust.

(c) As used in this act, the term ''chattels attached to mining property,'' or similar designation, includes anything which is deemed affixed or attached to land, or as forming part of the land.

(d) The term ''mining'' means gold or silver mining.

(e) The term ''real property'' means gold or silver mining property.

(f) The term ''operator'' includes all persons, firms or corporations engaged in gold or silver mining operations.

(g) ''Machinery'' and ''equipment'' shall mean ''gold or silver mining machinery'' and ''equipment.''

SEC. 24. Nothing contained in this act shall preclude any trustor under a deed of trust or any mortgagor of chattels or any mortgagor under a mortgage or any purchaser under a contract for the purchase of real property, or chattels attached to real property, from executing and delivering at any time a deed to his beneficiary, mortgagee or vendor, or the purchaser at any foreclosure sale or a redemptioner, as the case may be, and the execution and delivery of any such deed by any such trustor, mortgagor or purchaser shall constitute a waiver of the benefit of all the provisions of this act. The failure on the part of any trustor, mortgagor or purchaser or operator to file a petition within the times specified in this act, shall be deemed a waiver of the benefits of the provisions of this act.

SEC. 25. Any sale of property under a chattel mortgage, or of real property, or of chattels attached to real property, under a deed of trust, mortgage, or chattel mortgage, and any forfeiture made in violation of this act shall be voidable, except as against a bona fide purchaser or encumbrancer for value, at the instance of the record owner of such real or personal property at the time of such sale, or the operator at the time of such forfeiture; provided, that any action to avoid such sale or any deed executed pursuant thereto must be brought within one year of the date of such sale.

Sec. 26. There shall be no filing fees for the filing of any document with the county clerk under the provisions of this act.

Sec. 27. Until October 1, 1945, or six months after termination of the war, whichever shall first occur, no receiver shall be appointed at the instance of the mortgagee of any mortgage or the trustee or beneficiary of any deed of trust, with respect to real property or chattels attached to real property subject to mortgage or deed of trust, except in a suit or action for the foreclosure of such mortgage or deed of trust or for the enforcement of the covenants, or any thereof, contained in such mortgage or deed of trust, or in a proceeding ancillary to any such suit or action, or until after recording notice of default.

Sec. 28. If any section, clause or part of this act, or the application thereof to any person or circumstance, is finally determined by the courts to be unconstitutional such section, clause or part shall no longer be effective or such application shall no longer control, but all other sections, clauses or parts or the application thereof to other persons and circumstances shall continue in full force and effect; it being the intent of the Legislature to make this act as effective as possible to relieve operators in the manner herein provided.

Sec. 29. Whenever any petition under this act is to be or is being heard by the court, the interested parties may submit to the court, in writing, a composition of the indebtedness involved in the proceeding, or a compromise settlement of the proceeding, and the court shall have jurisdiction and may by its order confirm and approve such composition or settlement.

Sec. 30. Nothing contained herein shall be construed as affecting any rights which have accrued under Chapter 1, Statutes of the Extra Session of 1934, or shorten the time within which any action may be commenced.

Sec. 31. Nothing contained herein shall be construed as affecting any rights which have accrued under Chapter 7, Statutes of 1935; Chapter 348, Statutes of 1935; Chapter 5 or Chapter 167, Statutes of 1937; Chapter 86, Statutes of 1939; or Chapter 208, Statutes of 1941; or shorten the time within which any action may be commenced, or affect any proceedings taken thereunder.

Sec. 32. Whenever a proceeding is instituted in accordance with Sections 2, 3, or 4 of the act, the court may, upon cause shown, make a temporary order suspending the requirements for performing work and making payments under the contract or restraining the enforcement of liens for any of the items mentioned in Sections 3 or 4 hereof, pending final disposition of such proceedings, and may make such additional and supplementary orders as may be necessary for proper disposition of the case.

Sec. 33. No person shall be held liable in any proceeding in any court for damages, penalty, or forfeiture on account of any act done or omitted to be done in good faith in accordance with or in reliance upon any provision of this act, or any order or judgment of a court made pursuant to any such provision.

Sec. 34. For the purposes of this act, the term "person" includes any individual, partnership, firm, corporation, association, or other organization, or the legal representative of any of the foregoing.

Sec. 35. This act is hereby declared to be an urgency measure necessary for the immediate preservation of the public peace, health or safety within the meaning of Section 1 of Article IV of the Constitution and shall therefore go into immediate effect. A statement of the facts constituting such necessity is as follows:

The United States War Production Board has ordered the cessation of gold mining for the duration of the war. Many persons engaged in gold and silver mining face financial ruin as a result of this order unless given immediate relief.

SENATE BILL No. 320

CHAPTER 542

An act to add Section 2211 to the Public Resources Code, relating to the county mineralogist.

The people of the State of California do enact as follows:

Section 1. Section 2211 is added to the Public Resources Code, to read:

2211. A county mineralogist may be appointed by the board of supervisors of a county to serve at the pleasure of that board for a compensation fixed by that board and payable out of the county treasury. The expenses of maintaining an office, telephone, traveling and the expense of supplying necessary books, records and other supplies to said mineralogist shall be county charges.

[Approved by Governor May 17, 1943.]

SENATE BILL No. 1111

CHAPTER 749

An act to amend Section 10074 of, to add Sections 10009.5, 10023, 10024, 10025 and 11011.5 to, and to add Chapter 7, comprising Sections 10500 to 10601, to Part 1 of Division 4 of, the Business and Professions Code, relating to transactions in mineral, oil or gas property, regulating mineral, oil and gas brokers and salesmen and prescribing the powers and duties of the State Division of Real Estate with respect thereto.

[Approved by Governor May 26, 1943. Filed with Secretary of State May 26, 1943.]

The people of the State of California do enact as follows:

Section 1. Section 10009.5 is added to the Business and Professions Code, to read:

10009.5. "Provisions of this part relating to mineral, oil and gas brokerage" refers to the provisions of Chapters 1, 2, 6 and 7, of Part 1.

Sec. 2. Section 10023 is added to said code, to read:

10023. ''Mineral, oil and gas license'' refers to a person, whether broker or salesman licensed under Chapter 7 of this part.

Sec. 3. Section 10024 is added to said code, to read:

10024. ''Mineral, oil and gas broker'' refers to a person licensed as a broker under Chapter 7 of this part.

Sec. 4. Section 10025 is added to said code, to read:

10025. ''Mineral, oil and gas salesman'' refers to a person licensed as a salesman under Chapter 7 of this part.

Sec. 5. Chapter 7, comprising Sections 10500 to 10601, is added to Part 1 of Division 4 of said code, to read:

Chapter 7. Mineral, Oil and Gas Brokerage

Article 1. Scope of Regulation

10500. It is unlawful for any person to engage in the business, act in the capacity of, advertise or assume to act as a mineral, oil and gas broker or a mineral, oil and gas salesman within this State without first obtaining a mineral, oil and gas license from the division.

The commissioner may prefer a complaint for violation of this section before any court of competent jurisdiction, and the commissioner and his counsel, deputies or assistants may assist in presenting the law or facts at the trial.

It is the duty of the district attorney of each county in this State to prosecute all violations of this section in their respective counties in which the violations occur.

10501. A mineral, oil and gas broker within the meaning of this part is a person who, for a compensation, sells or offers for sale, buys, or offers to buy, lists, or solicits for prospective purchasers, or negotiates the purchase or sale or exchange of mineral, oil or gas property, or who, for compensation, negotiates loans on mineral, oil or gas property, leases or offers to lease, or negotiates the sale, purchase, or exchange of leases, rents, or places for rent, or collects rent or royalties from mineral, oil or gas property, for another or others.

10502. A mineral, oil and gas salesman within the meaning of this part is a natural person who for a compensation is employed by a licensed mineral, oil and gas broker to sell, or offer for sale, or to list, or to buy, or to offer to buy, or to negotiate the purchase or sale or exchange of mineral, oil or gas property, or to solicit for prospective purchasers of mineral, oil or gas property, or to negotiate a loan on mineral, oil or gas property, or to lease, or to negotiate the sale, purchase or exchange of leases, or offer to lease, rent or place for rent, any mineral, oil or gas property.

10503. Mineral, oil or gas property refers to land used for, intended to be used for, or concerning which representations are made with respect to, the mining of minerals or the extraction of oil or gas therefrom.

10504. Mineral, oil and gas broker within the meaning of this part includes any person who engages in the business of buying or leasing, or who takes an option on, mineral, oil or gas property, for the purpose of sale or resale, or lease or sublease, or assignment of a lease, or exchange, of such property or any part of such property.

10505. The provisions of this chapter do not apply to:

(a) Any person acting solely as a depositary under an oil or gas lease, or oil and gas lease, other than for purposes of sale.

(b) Any person who engages in any transaction pursuant to an order of a court of competent jurisdiction.

(c) Any person, and the officers and employees of such person, engaged in the business of drilling for or producing oil or gas, or of mining for or producing minerals.

10506. One act, for a compensation of buying or selling a mineral, oil or gas property of or for another, or offering for another to buy or sell or exchange a mineral, oil or gas property, or negotiating the purchase or sale or exchange of, or listing or soliciting prospective purchasers of mineral, oil or gas property, or negotiating a loan on or leasing or renting or placing for rent a mineral, oil or gas property, or collecting rent therefrom constitutes the person making such offer, sale or purchase, exchange or lease, or negotiating the loan, or so renting or placing for rent or collecting the rent or listing or soliciting, a mineral, oil and gas broker or salesman within the meaning of this part.

10507. (a) The provisions of this chapter, except Section 10512, do not apply to a real estate licensee while acting as such in connection with the sale, lease or exchange of real property (other than mineral, oil or gas property) or an interest therein, when the transfer of mineral, oil or gas property is purely incidental to the sale, lease or exchange of real property (other than mineral, oil or gas property).

(b) Any real estate licensee, who performs an act or engages in a transaction subject to this chapter, which act or transaction is incidental to his real estate business but not within subdivision (a), may secure a permit for such act or transaction from the commissioner without otherwise complying with the provisions of this chapter, except Section 10512. Not more than 10 permits per fiscal year may be issued under this section to any real estate licensee. The real estate permit fee shall be paid for each permit.

10508. No person engaged in the business or acting in the capacity of a mineral, oil and gas broker or a mineral, oil and gas salesman within this State shall bring or maintain any action in the courts of this State for the collection of compensation for the performance of any of the acts mentioned in this article without alleging and proving that he was a duly licensed mineral, oil and gas broker or mineral, oil and gas salesman at the time the alleged cause of action arose.

10509. It is unlawful for any licensed mineral, oil and gas broker to employ or compensate, directly or indirectly, any person for performing any of the acts within the scope of this chapter who is not a licensed mineral, oil and gas broker, or a mineral, oil and gas salesman licensed under the broker employing or compensating him.

No mineral, oil and gas salesman shall be employed by or accept compensation from any person other than the mineral, oil and gas broker under whom he is at the time licensed.

It is unlawful for any licensed mineral, oil and gas salesman to pay any compensation for performing any of the acts within the scope of this chapter to any mineral, oil and gas licensee except through the mineral, oil and gas broker under whom he is at the time licensed.

For a violation of any of the provisions of this section, the commissioner may temporarily suspend or permanently revoke the license of the mineral, oil and gas licensee in accordance with the provisions of this part relating to hearings.

10510. It is a misdemeanor, punishable by a fine of not exceeding fifty dollars ($50) for each offense, for any person, whether obligor, escrow holder or otherwise, to pay or deliver to anyone a compensation for performing any of the acts within the scope of this chapter, who is not known to be or who does not present evidence to such payor that he is a regularly licensed mineral, oil and gas broker at the time such compensation is earned.

For a violation of any of the provisions of this section, the commissioner may temporarily suspend or permanently revoke the license of the mineral, oil and gas licensee in accordance with the provisions of this part relating to hearings.

10511. Any person acting as a mineral, oil and gas broker or mineral, oil and gas salesman without a license shall, upon conviction thereof, if a natural person, be punished by a fine of not to exceed five hundred dollars ($500), or by imprisonment in the county jail for a term not to exceed six months, or by both such fine and imprisonment in the discretion of the court; or if a corporation, be punished by a fine of not to exceed five thousand dollars ($5,000).

10512. Every officer, agent or employee of any company, and every other person who knowingly authorizes, directs or aids in the publication, advertisement, distribution or circularization of any false statement or representation concerning any mineral, oil or gas property, and every person who, with knowledge that any advertisement, pamphlet, prospectus or letter concerning any mineral, oil or gas property or any written statement that is false or fraudulent, issues, circulates, publishes or distributes the same, or causes the same to be issued, circulated, published or distributed, or who in any other respect wilfully violates or fails, omits, or neglects to obey, observe or comply with any order, permit, decision, demand or requirement of the commissioner under the provisions of this part relating to mineral, oil and gas brokerage, is guilty of a misdemeanor, and shall be punished by imprisonment in the county jail for a term not to exceed six months, or by a fine of not to exceed five hundred dollars ($500), and, if a mineral, oil and gas licensee, he shall be held to trial by the commissioner for a suspension or revocation of his mineral, oil and gas license, as provided in the provisions of this part relating to hearings. It shall be the duty of the district attorney of each county in this State to prosecute all violations of the provisions of this section in respective counties in which the violations occur.

10513. All mineral, oil and gas licensees shall file reports with the commissioner of each act and transaction subject to this chapter undertaken by the mineral, oil and gas licensee. The report shall be filed at such times and in such manner and contain such information as may be prescribed by the commissioner by rule and regulation.

For a violation of the provisions of this section the commissioner may temporarily suspend or permanently revoke the license of a mineral, oil and gas licensee in accordance with the provisions of this part, relating to hearings.

Article 2. Licenses

10515. Application for license as mineral, oil and gas broker shall be made in writing to the commissioner. The application shall be accompanied by the mineral, oil and gas broker's examination fee and the original mineral, oil and gas broker's license fee and by the recommendation of two real estate owners of the county in which the applicant resides or has his place of business, certifying that the applicant is honest, truthful and of good reputation, and recommending that a mineral, oil and gas broker's license be granted to him.

If the applicant has resided, or has engaged in business for less than one year in the county from which the application is made, the application shall also be accompanied by the recommendation of two real estate owners of each of the counties where he has formerly resided or engaged in business during this period of one year prior to the filing of the application, certifying that the applicant is honest, truthful and of good reputation and recommending that a license be granted to the applicant.

10516. Application for license as mineral, oil and gas salesman shall be made in writing to the commissioner. The application shall be signed by the applicant and shall set forth the period of time during which he has been engaged in business, stating the name of his last employer and the name and place of business of the person then employing him, or in whose employ he is to enter. The application shall be accompanied by the mineral, oil and gas salesman's examination fee and the original mineral, oil and gas salesman's license fee and by the recommendation of his employer, if employed, certifying that the applicant is honest, truthful and of good reputation, and recommending that a mineral, oil and gas license be granted to the applicant.

10517. The commissioner may require such other proof as he may deem advisable concerning the honesty, truthfulness and good reputation of any applicant for a mineral, oil and gas license, or of the officers of any corporation, or of the members of any copartnership making such application, before authorizing the issuance of a mineral, oil and gas license. For this purpose the commissioner may call a hearing in accordance with the provisions of this part relating to hearings.

10518. In addition to the proof of honest, truthfulness and good reputation required of any applicant for a mineral, oil and gas license, the commissioner shall ascertain by written examination that the applicant, and in case of a copartnership or corporation applicant for a mineral, oil and gas broker's license that each officer, agent or member thereof through whom it proposes to act as a mineral, oil and gas licensee, has:

(a) Appropriate knowledge of the English language, including reading, writing and spelling, and of elementary arithmetic.

(b) A fair understanding of the general purposes and general legal effect of deeds, mortgages, chattel mortgages, contracts of sale, bills of sale, liens and leases, of the elementary principles of business economics, appraisals, and the purchase, sale, renting and leasing of personal property.

(c) A general and fair understanding of the obligations between principal and agent, of the rudiments of geology relating to minerals, oils and gas, and a familiarity with methods of mineral and oil exploration and production, as well as of the provisions of this part relating to mineral, oil and gas brokerage.

10519. The commissioner may, in his discretion, waive the examination of any applicant for a mineral, oil and gas broker's license who held an unrevoked or unsuspended mineral, oil and gas license on June 30th of the preceding fiscal year as an individual broker, an officer of a corporation, or member of a copartnership.

The commissioner may, in his discretion, waive the examination of any applicant for a mineral, oil and gas salesman's license who held an unrevoked or unsuspended mineral, oil and gas salesman's license on June 30th of the preceding fiscal year and who had previously qualified by passing the written examination.

10520. No mineral, oil and gas license gives authority to do any act specified in this chapter to any person, other than the person to whom the license is issued.

10521. When a mineral, oil and gas license is issued to a corporation, if it desires any of its officers other than its president, to act under its license as a mineral, oil and gas broker, it shall procure an additional license to so employ each of such officers. When a mineral, oil and gas license is granted to a copartnership, if it desires any of its members other than the one or ones through whom it is already licensed to act as a mineral, oil and gas broker, it shall procure an additional license to so employ each of such additional members.

10522. Each officer of a corporation through whom it is licensed to act as a mineral, oil and gas broker, and each member of a copartnership through whom it is licensed to act as a mineral, oil and gas broker, is, while so employed under such license a licensed mineral, oil and gas broker, but licensed only to act as such for and on behalf of the corporation or the copartnership, as officer or member, respectively.

10523. The mineral, oil and gas licenses of both broker and salesman shall be prominently displayed in the office of the mineral, oil and gas broker.

The mineral, oil and gas salesman's license shall remain in the possession of the licensed mineral, oil and gas broker employer until canceled or until the salesman leaves the employ of the broker.

10524. Immediately upon the salesman's withdrawal from the employ of the broker, the broker shall return the salesman's license to the commissioner for cancellation. A license canceled but not suspended or revoked may be reinstated within the fiscal year upon receipt of application therefor and the fee for the reinstatement of his license.

10525. Every licensed mineral, oil and gas broker shall have and maintain a definite place of business in the State of California which shall serve as his office for the transaction of business.

No mineral, oil and gas license authorizes the licensee to do business except from the location stipulated in the mineral, oil and gas license.

Notice in writing shall be given the commissioner of change of business location of a mineral, oil and gas broker, whereupon the commissioner shall issue a new mineral, oil and gas license for the unexpired period. The change or abandonment of business location without notification to the commissioner and the issuance by him of a new mineral, oil and gas license shall automatically cancel the mineral, oil and gas license theretofore issued.

10526. If the applicant for a mineral, oil and gas broker's license maintains more than one place of business within the State he shall apply for and procure an additional license for each branch office so maintained by him. Every such application shall state the name of the person and the location of the place or places of business for which such license is desired.

The commissioner may determine whether or not a broker is doing a mineral, oil and gas brokerage business at or from any particular location which requires him to have a branch office license.

10527. Each mineral, oil and gas broker shall erect and maintain a sign in a conspicuous place on the premises to indicate that he is a licensed mineral, oil and gas broker and his name shall be clearly shown thereon. The size and place of the sign shall conform to regulations that may be adopted by the commissioner.

10528. For a violation of any of the provisions of Sections 10523, 10524, 10525 and 10527, the commissioner may temporarily suspend or permanently revoke the license of the mineral, oil and gas licensee in accordance with the provisions of this part relating to hearings.

Article 3. Bonds

10540. Every mineral, oil and gas licensee shall file and maintain with the commissioner a bond in the penal sum of five thousand dollars ($5,000), issued by an admitted, corporate surety insurer, and running to the people of the State of California. The bond shall be conditioned that the licensee will obey all the provisions of this part relating to mineral, oil and gas brokerage, and complete compliance with all obligations assumed by him under his mineral, oil and gas license. In addition to any other remedy he may have, every person sustaining any injury for a breach of obligation may sue the surety for the recovery of any damages sustained by him. The liability of the surety shall not exceed five thousand dollars ($5,000) in the aggregate.

10541. The bond shall be continuous in form and remain in full force and effect and shall run concurrently with the license period and for any renewals thereof, as provided in Section 2852 of the Civil Code, unless terminated or canceled by action of the surety as provided by law or unless terminated or canceled as provided in this chapter.

10542. Upon the filing of notice with the commissioner by any surety of its withdrawal as surety for any licensee pursuant to Section 2851 of the Civil Code, the commissioner shall forthwith give notice to the licensee of the withdrawal which notice shall be by registered mail with request for return receipt and shall be addressed to the licensee at his main office as shown by the records of the commissioner. The license of any licensee shall be suspended upon the termination of the bond of the surety as provided in Section 2851 unless, prior to the termination, a new bond has been filed with the commissioner.

10543. A new bond may be filed at any time by the mineral, oil and gas licensee.

Article 4. Disciplinary Action

10560. Upon grounds provided in this article and the other articles of this chapter, the license of any mineral, oil and gas licensee may be revoked or suspended in accordance with the provisions of this part relating to hearings.

10561. The commissioner may, upon his own motion, and shall, upon the verified complaint in writing of any person, investigate the actions of any person engaged in the business or acting in the capacity of a mineral, oil and gas licensee, within this State, and he may temporarily suspend or permanently revoke a mineral, oil and gas license at any time if the licensee, within the immediately preceding three years, while a mineral, oil and gas licensee, in performing or attempting to perform any of the acts within the scope of this chapter, has been guilty of any of the following:

(a) Making any substantial misrepresentation.

(b) Making any false promises of a character likely to influence, persuade or induce.

(c) A continued and flagrant course of misrepresentation or making of false promises through mineral, oil and gas brokers or salesmen.

(d) Acting for more than one party in a transaction without the knowledge or consent of all parties thereto.

(e) Commingling the money or other property of his principal with his own.

(f) Any other conduct, whether of the same or a different character than specified in this section, which constitutes fraud or dishonest dealing.

10562. The commissioner may suspend or revoke the license of any mineral, oil and gas licensee, who within three years immediately preceding has done any of the following:

(a) Procured a mineral, oil and gas license, for himself or any salesman, by fraud, misrepresentation or deceit.

(b) Been convicted of a felony, knowledge of which the commissioner did not have at the time of last issuing a mineral, oil and gas license to him.

(c) Knowingly authorized, directed, connived at or aided in the publication, advertisement, distribution, or circulation of any material false statement or representation concerning his business or any mineral, oil or gas property offered for sale.

(d) Wilfully disregarded or violated any of the provisions of this part relating to mineral, oil and gas brokerage.

(e) Acted or conducted himself in a manner which would have warranted the denial of his application for a mineral, oil and gas license, or for a renewal thereof.

10563. When any mineral, oil and gas salesman is discharged by his employer for a violation of any of the provisions of this article prescribing a ground for disciplinary action, a verified written statement of the facts with reference thereto shall be filed forthwith with the commissioner by the employer and, if the employer fails to notify the commissioner as required by this section, the commissioner may temporarily suspend or permanently revoke the mineral, oil and gas license of the employer in accordance with the provisions of this part relating to hearings.

10564. The commissioner may deny, suspend or revoke the mineral, oil and gas license of a corporation as to any officer or agent acting under its mineral, oil and gas license, and the mineral, oil and gas license of a copartnership as to any member acting under its mineral, oil and gas license, without revoking the mineral, oil and gas license of the corporation or of the copartnership.

Article 5. Fees

10580. The fee for all mineral, oil and gas licenses shall at all periods of the fiscal year be the same as provided in this article. All mineral, oil and gas license fees shall be payable in advance of issuing the licenses and all examination fees shall be payable before taking the examination.

10581. All mineral, oil and gas licenses shall be issued for the fiscal year of July 1st to June 30th, inclusive, and shall expire on June 30th of each fiscal year at midnight.

10582. The definitions contained in this article are solely for the purposes of this article.

10583. An original mineral, oil and gas broker's license is a mineral, oil and gas license issued to a person who did not have a mineral, oil and gas broker's license on June 30th of the fiscal year previous to the fiscal year for which the license is issued.

10584. A renewal mineral, oil and gas broker's license is a mineral, oil and gas license issued to a person who had a mineral, oil and gas broker's license unrevoked and unsuspended on June 30th of the fiscal year previous to the fiscal year for which the renewal mineral, oil and gas license is issued.

10585. An original mineral, oil and gas salesman's license is a mineral, oil and gas license issued to a person who did not have a mineral, oil and gas salesman's or a broker's license either individually or as an officer of a corporation, or as a member of a copartnership, on June 30th of the fiscal year previous to the fiscal year for which the salesman's license is issued.

10586. A renewal mineral, oil and gas salesman's license is a mineral, oil and gas license issued to a person who had a mineral, oil and gas salesman's or a broker's license either individually or as an officer of a corporation, or as a member of a copartnership, on June 30th of the fiscal year previous to the fiscal year for which the salesman's license is issued.

10587. The amount of the mineral, oil and gas license fees prescribed for a license under this chapter is that fixed by the following provisions of this article.

10588. The original mineral, oil and gas broker's license fee is five dollars ($5). The mineral, oil and gas broker's examination fee is fifteen dollars ($15) which examination fee covers all examinations prior to the issuance of such original broker's license.

10589. The additional temporary broker's license fee is five dollars ($5).

10590. For a renewal mineral, oil and gas broker's license, the annual fee is five dollars ($5).

10591. If the licensee is a corporation, the renewal license issued to it entitles the president thereof, on behalf of such corporation, to engage in the business of mineral, oil and gas broker without the payment of any further fee. For each officer thereof other than the president of a licensed corporation, through whom it engages in the business of mineral, oil and gas broker, the annual fee is two dollars ($2) in addition to the fee paid by the corporation.

10592. If the licensee is a copartnership, the license issued to it entitles one member only of the copartnership to engage on behalf of the copartnership in the business of mineral, oil and gas broker, which member shall be designated in the application of the copartnership for a license. For each other member of the copartnership who on behalf of the copartnership engages in the business of mineral, oil and gas broker the annual fee shall be two dollars ($2) in addition to the fee paid by the copartnership.

10593. The original mineral, oil and gas salesman's license fee is two dollars ($2). The mineral, oil and gas salesman's examination fee is seven dollars and fifty cents ($7.50), which examination fee covers all examinations prior to the issuance of an original salesman's license.

10594. The additional temporary salesman's license fee is two dollars ($2).

10595. For a renewal mineral, oil and gas salesman's license, the annual fee is two dollars ($2).

10596. For a branch office broker's license the fee is one dollar ($1).

10597. For change of name or of address of licensee on the records of the division the fee is one dollar ($1).

10598. For transfer of a salesman's license on change of employer, the fee is one dollar ($1).

10599. For a duplicate license the fee is one dollar ($1).

10600. For reinstatement of a license within the fiscal year the fee is one dollar ($1).

10601. For a real estate permit, the fee is one dollar ($1).

Sec. 6. Section 10074 of said code is amended to read:

10074. After qualifying as such, neither the commissioner nor any of the deputies, clerks or employees of the division shall be interested in any business opportunity company, business opportunity brokerage firm, cemetery business, cemetery brokerage firm, mineral, oil or gas business, mineral, oil or gas brokerage firm, real estate company or any real estate brokerage firm, as director, stockholder, officer, member, agent, or employee, or act as a broker or salesman, or act as a copartner or agent for any broker or brokers, salesman or salesmen.

Sec. 7. Section 11011.5 is added to said code, to read:

11011.5. The questionnaire concerning any subdivision proposed to be sold as potential mineral, oil or gas property shall be accompanied by a filing fee of one hundred fifty dollars ($150).

Sec. 8. Any real estate licensee (as defined in Section 10014 of the Business and Professions Code) who has been licensed continuously for a period of five years preceding the effective date of this act may be granted a license as a mineral, oil and gas licensee (as defined in Section 10023 of the Business and Professions Code) without examination if he otherwise complies with and pays the fees (including the examination fee) required by Chapter 7 of Part 1, Division 4, of the Business and Professions Code and makes application to the Division of Real Estate within 90 days after this act takes effect.

MINERAL EXHIBIT AND STATISTICS

CURRENT NOTES

By Henry H. Symons *

A complete detailed annual report on the mineral production of California for 1942 will be available later as Bulletin 126 of the State Division of Mines.

STATISTICS

Bentonite

During 1942 the output of bentonite clay amounted to a total of 7,453 net tons, valued at $67,503, and came from four properties in San Bernardino County, two in Inyo County, and one each in Kern and San Diego Counties. The 1942 production showed a decrease in both amount and value as compared with that of 1941, which was 18,369 tons, worth $164,582.

Brick and Hollow Building Tile

During the year 1942 there was produced in California 117,739 M of common brick, valued at $1,296,449; 55,843 M of fire brick, valued at $3, 655,210; 7,353 M of glazed, pressed, vitrified, and fancy brick, worth $412,966; and 24,703 tons of hollow building tile, worth $344,342, the entire output having a total value of $5,708,967, as compared with the 1941 output which was 103,690 M of common brick, worth $1,158,590; 27,864 M of fire brick, worth $2,010,111; 6,371 M of glazed, pressed, fancy, and vitrified brick, worth $264,708; and 16,513 tons of hollow building tile, worth $165,388, with a total value of $3,598,797 for the year. It will be noted that fire brick practically doubled in both amount and value in 1942 over 1941 and that all other brick and building tile showed an increased output during the same period of time.

The 1942 brick and hollow building tile production was manufactured in 33 plants in 16 counties; eleven of which were in Los Angeles County; three in Contra Costa County; two each in Alameda, Sacramento, San Bernardino, San Diego, and San Joaquin Counties; and one each in Amador, Fresno, Orange, Placer, Riverside, San Luis Obispo, Santa Barbara, Santa Clara, and Tulare Counties.

Pumice and Volcanic Ash

The output of pumice and volcanic ash in California during 1942 totaled 55,603 short tons, valued at $209,539 f.o.b. rail shipping point. This material came from three properties each in Inyo and Siskiyou Counties, two each in Kern, Madera, and Mono Counties; and one each in Modoc, Napa, and San Luis Obispo Counties. The 1942 production showed a decrease in both amount and value as compared with that of 1941, which was 85,309 tons, worth $283,663 and the largest annual output reported in this State.

The material in 1942 from Inyo, Modoc, Mono, Napa, and Siskiyou Counties was 45,648 tons of lump pumice, worth $136,488, which was used for light-weight aggregate in concrete, acoustic plaster, abrasives,

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* Statistician and Curator, Division of Mines.

scouring bricks, insulating, and hen-house litter; while that from Kern, Madera, and San Luis Obispo Counties was 9,955 tons of volcanic ash or tuff variety, worth $73,051, and was employed in making soap, cleanser compounds, as a filler in concrete, in asphalt, and as a carrier for insecticides in dry agricultural sprays. A portion of the Kern County ash is going into the preparation of one of the nationally advertised brands of cleanser compounds.

ACCESSIONS TO THE EXHIBITS

The museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of economic and academic value. It ranks among the first five such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other States and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and sightseers. In addition to its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the State and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the Division of Mines, as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the exhibit are the following:

21131 SCHEELITE (tungsten ore). Locality: Lava Cap mine, Nevada City, Nevada County, California. Donor: John Siegfried. April 1943. In case 220.

21132 SCHEELITE. Locality: Amador Consolidated claim, Grass Valley, Nevada County, California. Donor: E. D. Drew. April 1943. In case 220.

21133 MANGANESE Ore. Locality: Redwood Materials quarry at Ralston Avenue, Belmont, San Mateo County, California. Donor: Henry G. Hubbard. April 1943. In case 229.

21134 SLAG. From: Copper cupola furnace operation at La Victoire copper mine, Mariposa County, California—1865. Donor R. B. Lamb. April 1943. In case 802.

21135 Paper SHALE which carries 28 gallons of oil to the ton. Locality: Nine miles east of Elko, Elko County, Nevada. Donor: G. J. Sielaff. May 1943. In case 504.

21136 WURTZILITE, GRAHAMITE, and WEIDGERITE. Locality: Top of Green River formation, at altitude of 9,000 ft. Leach mine on Roan Creek, Colorado. Donor: G. J. Sielaff. May 1943. In case 151.

21137 METACINNABAR and CINNABAR in "silica-carbonate" rock. Locality: Mount Diablo mine near Clayton, Contra Costa County, California. Donor: Worthen Bradley. June 1943. In case 205.

21138 CINNABAR in compacted sedimentary material. Locality: Sulphur Bank mine on south shore of Clear Lake, Lake County, California. Donor: Worthen Bradley. June 1943. In case 212.

21139 METACINNABAR in altered serpentine. Locality: Reed mine near Rumsey, Yolo County, California. Donor: Worthen Bradley. June 1943. In case 239.

21140 SMITHSONITE, $ZnCO_3$, a zinc carbonate and HEMIMORPHITE, H_2ZnSiO_5, a basic silicate of zinc. Locality: Carbonate King zinc mine, Ivanpah Range, San Bernardino County, California. Donor: W. F. Huston. June 1943. In case 225.

21141 STREAM TIN (cassiterite). Locality: Sullivan Creek, Hot Springs district, Alaska. Donor: Konrad Obrist. July 1943. In case 312.

21142 Crystallized GOLD. Locality: Grit claim, El Dorado County, California: mined August 1865. Donor: Marie E. E. Berton (nee Fricot) in memory of her father Jules Fricot. August 1943. In safe #2.

21143 ARAGONITE ($CaCO_3$) crystals on fracture face in massive CHROMITE. Locality: Grau pit, McLaughlin-Applegarth lease; sec. 17, Elder Creek, Tehama County, California. Donor: Geo. A. Applegarth. September 1943. In case 121.

21144 CINNABAR and RHODOCHROSITE in Franciscan chert. Locality: Twelve miles east of Covelo, Mendocino County, California. Donor: Harold Smith. September 1943. In case 309.

21145 SCHEELITE (crystal). Locality: Auldridge mine, near Kernville, Kern County, California. Donor: Fred and Austin Demetriff. October 1943. In case 150.

LABORATORY

LABORATORY NOTES FOR JULY QUARTERLY

By George L. Gary *

No. 124 Tetrahedrite, a gray sulphantimonate of copper, Cu_3SbS_3, has been found in the Morningstar Mine in the Mogul mining district, Alpine County.

No. 125 A large deposit of cinnabar in brecciated chert and sandstone has been developed by diamond drilling on the Beattie ranch, 10 miles northwest of Cloverdale, Mendocino County.

No. 126 Mercury occurs in small amounts with cinnabar on the Beattie ranch, 10 miles northwest of Cloverdale, Mendocino County.

No. 127 Correction: State Mineralogist's Report XXXV, July, 1939, page 343, No. 29—Hubernite should be Hubnerite.

No. 128 Crystals of plum-colored diaspore, $Al_2O_3H_2O$ occur in chlorite schist near Esmeralda, Calaveras County. This is the first occurrence in California of this mineral in crystal form.

End of July 1943

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* Mineral Technologist, Division of Mines.

LIBRARY

LIBRARY REPORT

By Henry G. Hubbard *

OUTLINE OF REPORT

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INTRODUCTION

The library of the Division of Mines contains more than 6,000 selected volumes on mines, mining, and allied subjects. It is also the repository for reports and bulletins of technical departments of Federal and State governments and educational institutions both domestic and foreign. Current copies of newspapers published in the mining centers of the State are also available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY AND UNITED STATES BUREAU OF MINES

The library of the Division of Mines has available for public reference the following publications of the United States Geological Survey: Annual Reports, Monographs, Professional Papers, Bulletins, Water-Supply Papers, Mineral Resources, Folios of the Geologic Atlas of the United States (broken file), Maps with Descriptive Text (broken file), Administrative Publications (broken file); and the following publications of the United States Bureau of Mines: Bulletins, Technical Papers, Economic Papers (broken file), Mineral Resources of the United States, Monographs (broken file), Reports of Investigations, Information Circulars.

Reports on California recently received from the Survey and Bureau of Mines include:

U. S. Geological Survey

Bulletins

931-Q	Quicksilver and Antimony Deposits of the Stayton District, California. 1942.
931-S	Manganese Deposits in the Paymaster Mining District, Imperial County, California. 1942.
936-D	Chromite and Quicksilver Deposits of the Del Puerto Area, Stanislaus County, California. 1942.
936-F	Quicksilver Deposits of the Parkfield District, California. 1942.
938	Bibliography of North American Geology for 1940-1941.

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* Librarian, Division of Mines.

Water-Supply Papers

844 Floods of March 1938 in Southern California. 399 pp., 26 pls., 40 figs.
930 Surface Water of The Great Basin in California. 1942.
931 Surface Water of Pacific Slope Basins in California. 1942.

Topographic Maps

Chileno Canyon Quadrangle, Los Angeles County, California. 1942.
Corona and Vicinity Quadrangle, Riverside and San Bernardino Counties, California. 1942.
Eureka Quadrangle, Humboldt County, California. 1942.
Point Loma Quadrangle, San Diego County, California. 1942.

Professional Paper

197-D The Basin and Range Province in Utah, Nevada, and California. 1943.

U. S. Bureau of Mines

Bulletins

431 Mechanical Concentration of Gases.
439 Some Essential Safety Factors in Tunnelling.
451 Syllabus of Clay Testing. Part I. 1943.

Technical Paper

632 Theoretical Calculations for Explosives.

Reports of Investigation

Nos. 3693; 3696; 3700; 3704; 3706-3711 incl.; 3713.

Information Circulars

Nos. 7225; 7227; 7228; 7233; 7234; 7236; 7237; 7242.

PUBLICATIONS OF STATE SURVEYS

A broken file of mining and geological publications, issued by the organizations listed below, may be consulted in the library of the Division of Mines.

Alabama Geological Survey, University.
Alaska (Territorial Commissioner of Mines), Juneau.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Indiana Division of Geology, Indianapolis.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology and Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
New York Science Division, Albany.
North Carolina Geological and Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.

West Virginia Geological Survey, Morgantown.
Wisconsin Geological and Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

PUBLICATIONS OF FOREIGN GOVERNMENTS

Publications of the following foreign governments are received and current issues may be consulted in the library. Earlier issues of foreign-language publications have been loaned to the California Academy of Sciences in Golden Gate Park, because of the limited storage space at the Division's offices in the Ferry Building. They may, however, be consulted at the Academy.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum of Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia Geological Survey, Perth.

PUBLICATIONS OF FOREIGN AND DOMESTIC SOCIETIES AND EDUCATIONAL INSTITUTIONS

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Missouri School of Mines and Metallurgy, Rolla.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economic Paleontologists and Mineralogists, Tulsa, Oklahoma.
Southern California Academy of Sciences, Los Angeles.
Stanford University, Palo Alto, California.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

CURRENT MAGAZINES

Current issues of the technical magazines listed below are on file in the reading room of the library, and may be consulted.

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

NEWSPAPERS

Current issues of the following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Courier Free Press, Redding, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mining Press, Reno, Nevada.

Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Press-Citizen, Lone Pine, California.
Placer Herald, Auburn, California.
Placerville Times, Placerville, California.
Plumas Independent, Quincy, Caifornia.
Printer-Review, Barstow, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

NEW BOOKS

Recent accessions to the library are the following books:

T. A. RICKARD—*Retrospect* (Autobiography): McGraw-Hill Book Co., 402 pp., 1937. (Donated by Elisabeth L. Egenhoff).

NEILL C. WILSON—*Silver-Stampede* (California's Panamint Mts.): The Macmillan Company, 344 pp., 1937. (Donated by Elisabeth L. Egenhoff).

SAMUEL A. GRAHAM and EARL C. O'ROKE—*On Your Own* (How to take care of yourself in wild country. A manual for field and service men): The University of Minnesota Press. 150 pp., 1943.

EDWARD H. KRAUS, WALTER F. HUNT, and LEWIS S. RAMSDELL—*Mineralogy.* (An introduction to the study of minerals and crystals): McGraw-Hill Book Co., 638 pp., 1936.

DUNCAN A. MacINNES—*The Principles of Electrochemistry,* 478 pp. Reinhold Publishing Corp., 1939. (F. W. Bradley Memorial Book Fund).

AMERICAN SOCIETY for TESTING MATERIALS—*1942 Book of A. S. T. M. Standards*: 3 parts, about 5000 pp. Published by the Society. (F. W. Bradley Memorial Book Fund).

RAND McNALLY CO.—*World Atlas*—Premier Edition, 270 pp., more than 140 maps in color, also tables, charts and indexes. 1942.

SERVICES OF THE DIVISION OF MINES

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January 1922, and continued until March 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September 1923. For the same reason, beginning with the January 1924 issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January 1933 chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

TYPES OF REPORTS

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire State of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

Reports of District Mining Engineers

In 1919-1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the locations of the branch offices are shown on the frontispiece outline map of the State.

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

Special Articles

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Division, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

MAIL AND FILES

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

COMMERCIAL MINERAL NOTES

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial

minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

Publications of the Division of Mines

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-three years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for advancing the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

Write for latest revised price list.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. Price $1.50, sales tax $0.04	1.54
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper Price $0.50, sales tax $0.01	.51
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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 39 OCTOBER 1943 No. 4

CALIFORNIA JOURNAL
OF
MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
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STATE DIVISION OF MINES
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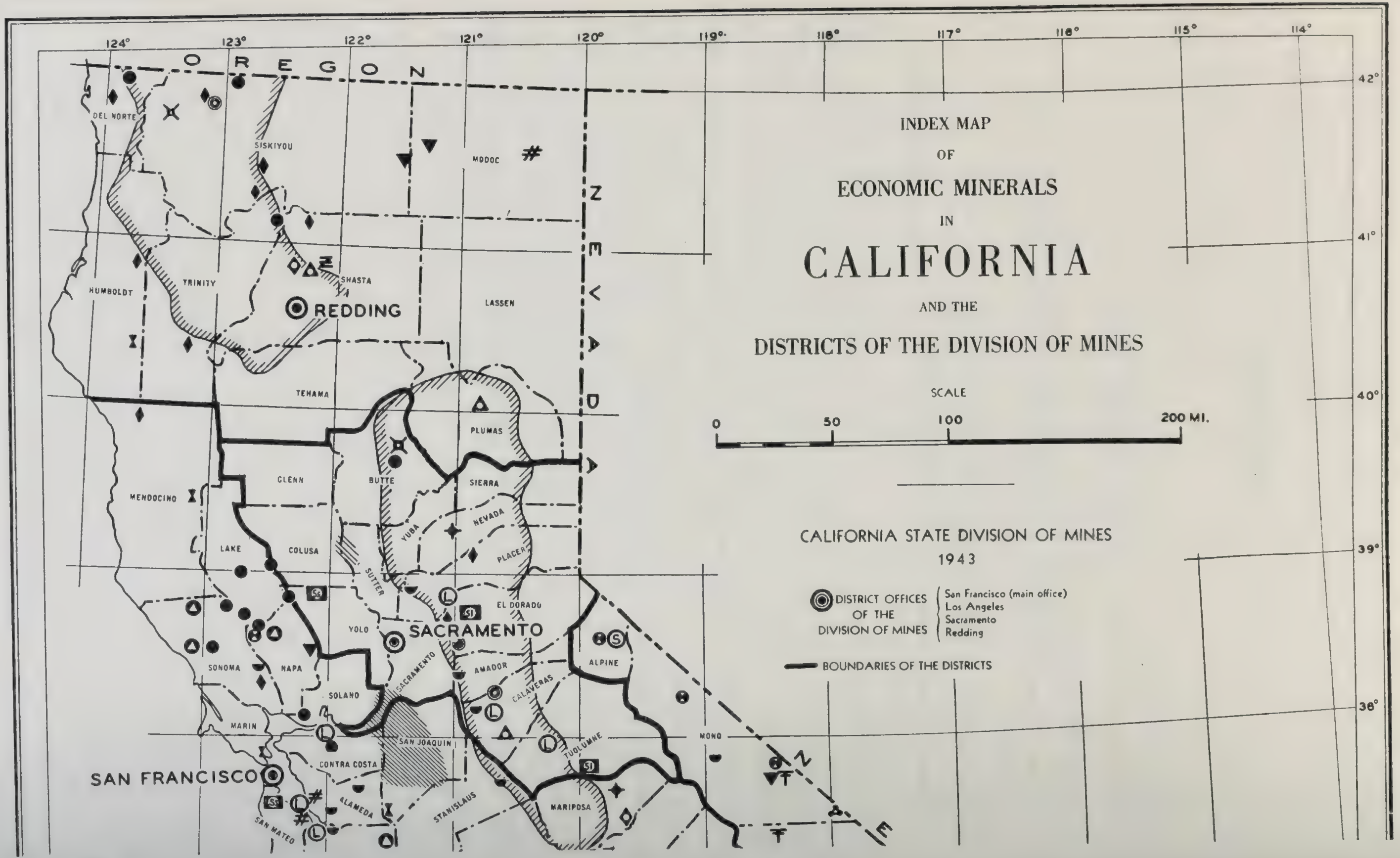
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1943

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123°
122°
121°
120°
119°
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116°
115°
114°
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OREGON
NEVADA
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
REDDING
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
YUBA
NEVADA
PLACER
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EL DORADO
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SACRAMENTO
ALPINE
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AMADOR
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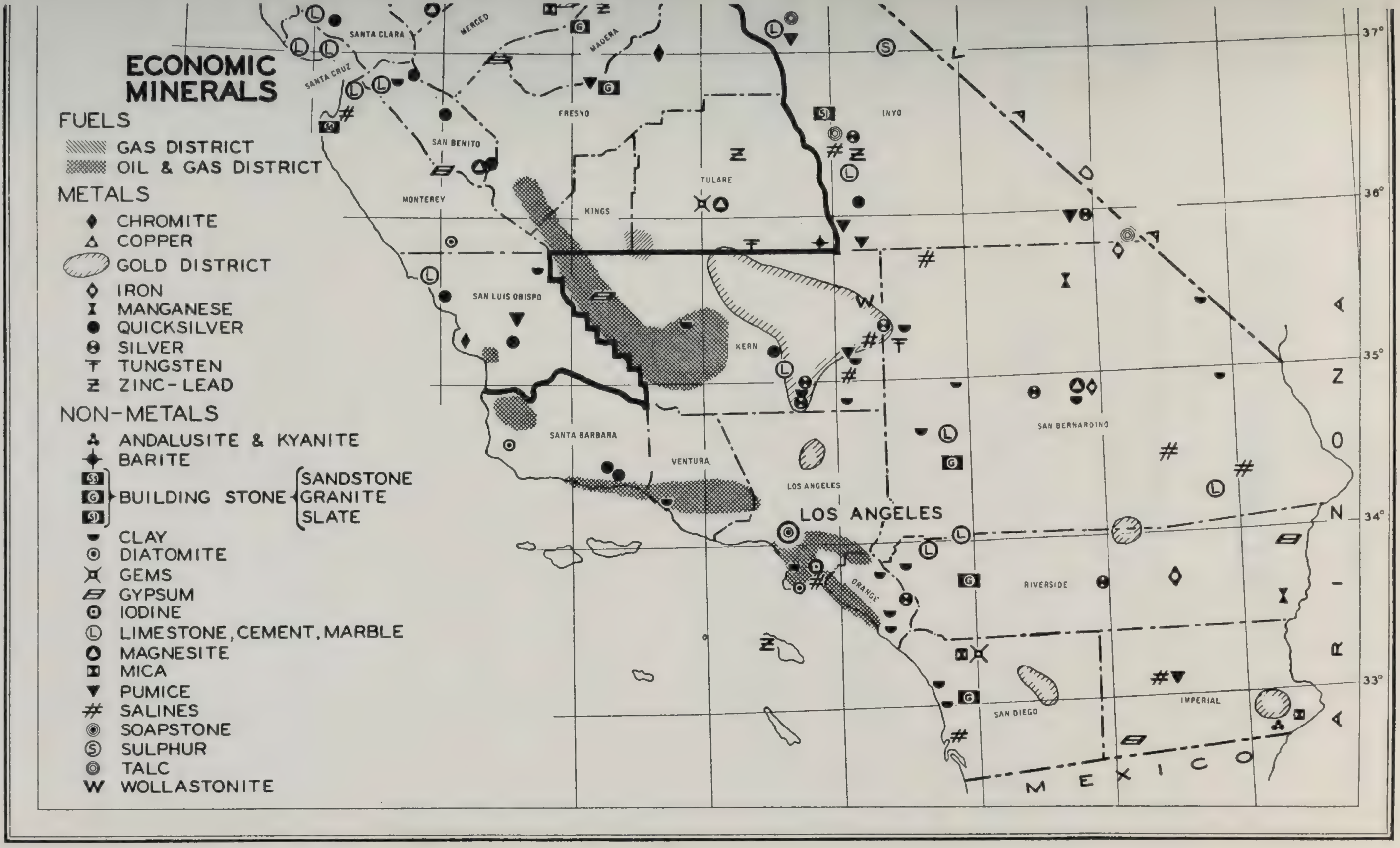
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FUELS
GAS DISTRICT
OIL & GAS DISTRICT
METALS
CHROMITE
COPPER
GOLD DISTRICT
IRON
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SULPHUR
TALC
WOLLASTONITE
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
FRESNO
INYO
SAN BENITO
TULARE
MONTEREY
KINGS
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
NEVADA
ARIZONA
MEXICO
37°
36°
35°
34°
33°

ADMINISTRATION

ADMINISTRATIVE REPORT

By Walter W. Bradley, State Mineralogist

Personnel

Henry G. Hubbard, junior mining engineer in the San Francisco headquarters office of the division, resigned in August to engage in private practice in the State of Nevada.

New Publications

BULLETIN 118 (final cloth-bound volume), *Geologic Formations and Economic Development of the Oil and Gas Fields of California*, 774 pages, well illustrated with photographs, charts, and maps, and with the state-wide map (Economic Mineral Map No. 2) in a pocket.

COMMERCIAL MINERAL NOTES, August, September, October, 1943. These 'Notes' contain the list of 'mineral deposits wanted' and 'mineral deposits for sale', issued in the form of a mimeographed sheet monthly. It is mailed to those on the mailing list for the *California Journal of Mines and Geology*. It may be separately subscribed for at 25¢ per year.

LOS ANGELES FIELD DISTRICT

MINERAL RESOURCES OF SAN BERNARDINO COUNTY

By W. B. Tucker* and R. J. Sampson**

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HISTORY

This county, created by an act of the Legislature in April 1853, is unique in that it is the largest county in the United States. Although part of its territory was allocated in 1893 to the then new county of Riverside, it still retains 20,157 square miles, an area which exceeds that of Massachusetts, Connecticut, Rhode Island, and Delaware, combined. It was named for San Bernardino of Siena by the Franciscan priests who visited the valley south of the San Bernardino Range on May 20, 1810.

The city of San Bernardino, which now has a population of approximately 60,000, was founded by Mormons from Salt Lake City in 1851.

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Manuscript submitted for publication October 15, 1943.

GEOGRAPHY

San Bernardino County is located in the southeastern part of California. It is bounded on the north by Inyo County, on the east by Arizona and Nevada, on the south by Riverside County, and on the west by Los Angeles and Kern Counties.

Of its area, approximately 18,500 square miles is desert; the remaining 1657 square miles embraces the timbered south slope of the San Bernardino Mountains and the fertile citrus groves of the San Bernardino Valley. Its boundaries contain practically all of the arid region known as the Mojave Desert. In this wide expanse of sand practically the only vegetation is greasewood and cactus; but many of the mountain ranges, buttes, and hills which rise from it are highly mineralized.

TRANSPORTATION

Three railroad lines cross the county: The Atchison, Topeka and Santa Fe; the Union Pacific; and the Southern Pacific. Operations of the Tonopah and Tidewater were recently discontinued. Each of these lines affords transportation to the Middle Western and Eastern States, as well as nearby western seaports. Two transcontinental highways traverse the county and there are numerous excellent state and county roads which make accessible practically all parts of this large county. The most notable addition to these secondary roads in recent years are those which were built in connection with the Metropolitan Water District Colorado River Aqueduct and the power lines from the Colorado River projects to the western centers of population.

MINERAL RESOURCES

The mineral production of San Bernardino County is shown in the table printed herein.

Although statistics prior to 1894 are available on the gold and silver production only, this county had a recorded production of $348,613,052 through 1941. If petroleum and natural gas are excluded this far exceeds the production of any other county in the state. It also leads in the variety of minerals commercially produced. Thirty-one different mineral substances were produced in 1941. These included antimony, bentonite, borates, bromine, pottery clay, calcium chloride, copper, feldspar, gold, granite, lead, limestone, lithia salts, manganese, marble, petroleum, potash, quicksilver, salt, silica (quartz), silver, soda, strontium minerals, talc, and tungsten ore.

In December 1942, in accordance with Order L-208 of the War Production Board, all gold mining in the county was stopped, with the exception of one or two properties whose ores carry a little copper and the high silica content of which makes them desirable in the smelting of copper ores. Silver is produced only as a by-product from ores of strategic metals.

Search for and development of strategic minerals has been stimulated by the creation of a stable market for a definite period of time by the Metals Reserve Company, liberalization of policy toward mining loans by the Reconstruction Finance Corporation and the establishment of Government stock piles at various points in the West. San Bernardino County has been most directly affected by the stock piles at Parker and Phoenix, Arizona, as well as Jean, Nevada, where zinc carbonates are accumulated. This has resulted in much prospecting and some development.

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MINERAL PRODUCTION OF SAN BERNARDINO COUNTY, 1880-1941[4]

Year	Gold, value	Silver, value	Copper		Lead		Borates, value	Gypsum		Salt		Cement		Lime		Limestone		Brick		Marble		Miscellaneous stone,[1] value	Gems, value	Miscellaneous and unapportioned		
			Pounds	Value	Pounds	Value		Tons	Value	Tons	Value	Barrels	Value	Barrels	Value	Tons	Value	M	Value	Cubic feet	Value			Amount	Value	Substance
1880																										
1881	$9,000	$100,000																								
1882	20,000	150,000																								
1883	30,000	1,050,000																								
1884	32,000	2,850,000																								
1885	23,000	2,363,438																								
1886	56,464	1,204,750																								
1887	27,550	1,131,268																								
1888	25,000	1,200,000																								
1889	10,737	621,520																								
1890	17,335	795,465																								
1891	62,970	711,157																								
1892	47,037	67,072																								
1893	165,000	447,020																								
1894	130,420	148,243					$726,509			1,000	$3,000	8,000	$21,600	40,000	$32,000	5,000	$6,250					$31,122				
1895	131,360	210,410					555,000			3,841	20,101	16,253	32,556	57,564	57,674	30,000	30,000					37,072				
1896	98,723	130,714					650,500			3,000	15,000	9,000	27,000	37,427	34,977	17,500	17,500			500	$3,000	28,476				
1897	100,373	54,407					1,050,000					15,000	60,000	12,000	12,000											
1898	261,512	32,000					1,120,000					50,000	150,000	50,000	35,000	6,600	6,600	2,000	$10,500	1,200	8,000	15,040				
1899	164,599	125,603	1,369,878	$232,339			1,106,000					60,000	180,000	16,000	16,100	16,440	14,810	1,000	8,000	4,500	625	11,276				
1900	247,949	172,759	1,920,000	297,600	10,000	$400	999,340					52,000	121,000	26,261	33,261	7,067	7,067					65,757	$20,000			
1901	399,693	57,164	50,000	7,575	500	20	898,130					71,800	159,842	38,783	43,028	54,210	76,710					100,777	20,000			
1902	394,036	58,972	338,480	41,008	59,340	2,070	2,198,600					96,000	273,600	76,352	65,532	48,958	51,578	60	1,500	8,005	15,600	192,400	11,600			
1903	381,197	59,199	60,400	7,852	14,000	504	495,000					100,000	157,000	39,923	28,692	52,813	64,613	100	8,000	35,000	41,600	200,961	10,000			
1904	595,528	13,025	169,477	17,270										25,000	21,500	28,421	42,576	2,500	17,500	31,116	53,400	158,659		4,000 cu ft	$2,000	Sandstone
1905	473,563	19,595	52,603	8,200										17,024	14,740	27,357	51,395			40,100	40,000	147,197	65,000			
1906	354,830	33,765	514,031	99,207										20,910	17,146	10,837	35,990	1,800	13,600	7,200	25,000	38,479		10 tons	5,500	Tungsten
1907	155,676	81,339	514,282	102,556	34,211	1,522								8,600	8,600	74,709	139,158	1,665	15,555	6,452	20,946	147,942				
1908	160,511	35,704	516,940	71,079	409,570	17,218		20,000	$70,000	90	650					104,236	97,466	1,050	7,350	150	500	231,242	200			
1909	40,071	13,570	316,300	40,418	310,200	13,254		12,500	43,000	3,500	14,000					22,197	41,395	1,709	11,966	50,000	125,000	173,777	200	300 tons	3,000 4,035,856	Pottery clay Unapportioned, 1900-1909
1910	65,093	10,164	5,412	659	134,312	5,972		31,519	70,357	3,000	9,000					224,610	157,715	1,910	11,460			95,126	1,120	430 tons 108,000 gals. 60 tons 100 tons	4,300 25,000 840 1,000	Pottery clay. Mineral water. Barytes. Soapstone.
1911	127,367	35,542	668,459	53,311	161,338	7,260		20,554	66,505	3,600	13,800					245,102	177,080			135	405	167,213		920 tons	4,060	Pottery clay
1912	293,000	49,962	1,937,155	310,636	94,852	4,265		21,000	67,000	3,600	12,600	[2]2,161,000	2,90[illegible] 200			80,156	97,507	1,340	8,040			580,524	450	350 tons 200 tons 50 tons	350 1,200 650	Pottery clay. Mineral paint. Barytes.
1913	356,824	44,413	497,852	77,167	279,241	12,287		25,000	74,000	3,040	10,573	[3]		121,544	113,850	25,696	35,464	350	2,100			304,312	550	4,500 gals.	3,000 1,301,304	Mineral water. Other minerals.
1914	205,000	40,000	19,069	2,538	45,110	1,759		17,332	49,150	482	2,892	[3]		54,637	93,100	23,006	20,550	25	1,250			131,078		44,100 gals. 50 tons 140 tons	5,100 601 400 1,240,575	Mineral water Mineral paint. Glass sand. Other minerals.
1915	416,967	94,165	209,440	36,852	169,183	7,952		[3]		542	3,324	915,000	980,000	[3]		68,500	68,500	400	2,400	[3]		178,528		37,450 gals. 864 tons 30,848 lbs.	7,350 840,947 4,941 82,310	Mineral water. Tungsten concentrates. Zinc. Dolomite, gypsum, lime, manganese, marble, mineral paint, soapstone, and talc.
1916	279,513	67,140	1,577,901	358,164	473,501	46,402		[3]		2,355	13,830	1,036,000	1,240,000	151,670	54,317	65,174	63,456	[3]				172,454	1,[illegible]	7,500 cu ft 40,500 gals. 1,921 tons 707,0[illegible] lbs	2,500 6,500 3,915,434 94,[illegible] 217,265	Granite. Mineral water Tungsten concentrates. Zinc. Brick, dolomite, feldspar, gypsum, manganese, mineral paint, pumice, potash, talc, strontium.
1917	154,970	88,930	1,220,356	333,157	2,293,541	197,245		[3]				1,323,931	1,072,054	[3]		[3]		[3]				111,158		235 tons 11,300 gals. 14,670 tons 3,050 tons 1,943 tons 38,735 lbs.	2,350 157,571 6,050 1,620 2,049,120 37,000 2,447,720 3,951 114,534	Granite. Lime and limestone. Manganese. Mineral water. Potash. Strontium. Tungsten concentrates. Zinc. Brick, pottery clay, dolomite, feldspar, gems, gypsum, iron ore, mineral paint, salt, soda, talc.
1918	29,225	65,712	1,580,998	390,507	667,978	47,426		[3]				1,027,635	1,453,062	[3]		10,552	13,323			[3]		48,451	[3]	270 tons 601,500 gals. 27,545 tons 430 tons 2,900 tons 1,347 tons 2,524 lbs.	810 60,150 3,428,443 4,210 33,000 1,911,966 257 122,349	Dolomite. Mineral water. Potash. Talc. Strontium. Tungsten concentrates. Zinc. Gems, granite, gypsum, iron ore, lime, magnesite, marble, mineral paint, salt
1919	39,769	427,717	236,033	47,700	105,798	5,607	[3]	19,613	50,154			1,078,943	1,717,998	[3]								183,358	[3]	800,000 gals. 21,171 tons 3,601 tons	32,000 1,670,919 10,845 443,492	Mineral water. Potash. Talc. Borax, pottery clay, dolomite, gems, lime, tungsten
1920	79,195	1,212,957	5,380	691	115,876	9,270	440,411	[3]		202	1,220	1,681,283	3,051,079	[3]		[3]						169,991	[3]	95 tons 1,110,100 gals 15,435 tons	890 156,720 1,082,037 330,551	Pottery clay. Mineral water. Potash. Dolomite, gems, granite, gypsum, iron ore, lime, limestone, soda, talc.
1921	217,668	3,210,706	17,054	2,200	22,512	1,027	338,905	[3]		13,279	67,782	1,964,926	4,633,437			21,562	106,195					145,572	[3]	683 tons 7,202 tons 2,750 tons	22,98[illegible] 211,06[illegible] 43,375 374,720	Calcium chloride. Potash. Talc Pottery clay, dolomite, feldspar, gems, granite, gypsum, iron ore, lime, mineral water, pumice, soda.
1922	125,728	2,374,918	13,452	1,810	11,188	615	[3]	[3]		12,222	54,259	2,770,953	4,156,430	[3]		2,200	7,800					[3]			1,826,304	Borax, calcium chloride, fuller's earth, gems, gypsum, lime, mineral water, potash, soda, talc, miscellaneous stone.
1923	210,923	2,225,959	13,328	1,959	34,477	2,413	[3]	[3]		17,350	65,550	3,554,764	5,478,[illegible]12	[3]		5,559	25,324					351,151		8[illegible] tons 7,248 tons	12,63[illegible] 123,21[illegible] 2,276,510	Clay (pottery). Talc Borates, calcium chloride, gems, gypsum, lime, mineral water, potash, soda (trona), tungsten concentrates.
1924	187,573	1,531,595	17,667	2,314	31,668	2,533				29,699	99,791	4,354,119	7,671,370	[3]		14,375	45,137					355,946		7,234 tons	125,926 2,720,243	Talc. Borates, calcium chloride, clay (pottery), fuller's earth, gypsum, lime, mineral water, petroleum, potash, soda (trona), tungsten, concentrates.
1925	157,374	1,378,392	6,249	885	61,480	5,340				28,310	101,055	5,070,281	8,828,[illegible]44	17,415	124,440	13,239	27,509					395,048		1,540 tons	11,000 3,150,468	Clay (pottery) Borates, calcium chloride, fuller's earth, mineral water, petroleum, potash, soda (trona), talc, tungsten, concentrates.
1926	106,875	551,644	171,232	23,972	195,536	15,643				22,522	85,463	5,135,840	9,273,627	[illegible]3,680	96,310	11,226	49,904					404,68[illegible]		2,268 tons 2,806 tons 8,134 tons	10,605 [illegible] 142,[illegible] 3,384,150	Clay (pottery) Soda (trona) Talc Borates, calcium chloride, fuller's earth, magnesite, mineral water, petroleum, potash, silica, tungsten concentrates, zinc.
1927	82,225	447,125	197,132	25,824	125,692	7,[illegible]19						5,557,339	9,823,839	12,170	92,163	550,011	348,354					31[illegible],47[illegible]		1,798 tons 6,544 tons	26,963 43,4[illegible]8 4,925,55[illegible]	Fuller's earth. Talc Borates, calcium chloride, clay (pottery), gems, mineral water, onyx, petroleum, potash, salt, silica, soda (trona), talc, tungsten concentrates.
1928	91,717	362,741	106,351	15,314	38,097	2,209				42,244	180,470	4,383,383	7,137,600	14,015	106,312	11,201	40,224					32[illegible],541	[3]	2,1[illegible] tons	12,215 5,873,033	Clay (pottery) Antimony, borates, calcium chloride, fuller's earth, gems, mineral water, potash, soda, talc, and tungsten
1929	44,984	180,756	81,846	14,405	53,532	3,373				24,943	114,796	3,576,905	4,603,301	1[illegible],145	77,340	15,520	40,753					62[illegible],111	1,510	[illegible] tons	15,574 5,474,4[illegible]	Clay (pottery). Barite, borates, calcium chloride, manganese, mineral water, potash, volcanic ash, soda, talc, tungsten
1930	59,442	178,496	40,022	5,2[illegible]	45,653	2,283	[3]			[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]			4[illegible],912		2,01[illegible] tons	14,916 [illegible]89,971	Clay (pottery). Barites, borates, brick, calcium chloride, cement, fuller's earth, gems, lime, limestone, manganese ore, mineral water, potash, salt, soda, talc, tungsten
1931	54,099	32,453	6,072	553	15,763	585	[3]			[3]		[3]				15,128	50,608	[3]				4[illegible],246	[3]	3,[illegible] tons 1,[illegible]20 tons	29,7[illegible]3 [illegible] [illegible]	Bentonite. Pottery clay Barite, borates, brick, calcium chloride, cement, gems, lime, manganese, mineral water, potash, pumice, iron ore, salt, silica (quartz), soda, talc, tungsten
1932	137,979	50,241	6,183	357	23,371	701	[3]			[3]		[3]		[3]		8,619	23,717	[3]				197,230	[3]	1,096 tons	6,4[illegible] 5,6[illegible]	Pottery clay Barite, bentonite, borates, brick, calcium chloride, cement, gems, lime, mineral water, petroleum, potash, salt, soda, talc
1933	116,074	33,817	7,871	504	[illegible]7,036	634	[3]					[3]		[3]		[3]		[3]				[illegible]15,154		275 tons 1,678 tons 780 tons 8,531 tons	2,515 6,042 [illegible] [illegible] [illegible]	Barite Bentonite. Pottery clay Talc Borates, brick, calcium chloride, cement, fluorspar, lime, limestone, mineral water, petroleum, potash, volcanic ash, salt, soda, tungsten
1934	[illegible]994	147,597	25,606	[illegible],048	1[illegible]3,497	3,82[illegible]	[3]			[3]		[3]		3,996	30,846	1[illegible]	29,749	[3]				165,057		1,185 tons	7,844 [illegible]	Pottery clay. Barite, bentonite, borates, brick, calcium chloride, cement, fluorspar, gems, iron ore, manganese, mineral water, potash, salt, soda, talc, tungsten ore
1935	270,[illegible]20	114,736	15,553	1,623	123,776	4,951	[3]			[3]		[3]		[3]		[3]		[3]				19[illegible]2		4,028 tons [illegible]23 tons	17,6[illegible]5 [illegible] [illegible]25,44[illegible]	Bentonite. Pottery clay Borates, brick, calcium chloride, cement, iron ore, lime, [illegible] onyx, mineral water, potash, salt, soda, talc, tungsten ore.
1936	140,105	182,343	10,110	930	115,621	5,318	[3]			[3]		[3]		[3]		1[illegible],046	52,046	[3]		[3]		209,357		4,074 tons 9,781 tons	68,062 43,[illegible] 14,698,127	Bentonite Pottery clay Borates, brick, calcium chloride, cement, gems, iron ore, lime, onyx, mineral water, petroleum, potash, salt, soda, talc, tungsten ore, zinc.
1937	218,325	277,842	[illegible]8,760	1,4[illegible]0	[illegible]6,213	6,260	[3]			[3]		[3]		[3]		25,967	76,850	[3]		[3]		3[illegible]7,137		5,7[illegible] tons 7,279 lbs	50,252 1,1[illegible] 15,070,[illegible]55	Pottery clay Zinc Bentonite, borates, brick, calcium chloride, cement, fluorspar, granite, iron ore, lime, onyx, mineral water, salt, soda, petroleum, talc, tungsten ore.
1938	409,2[illegible]0	3[illegible],381	24,723	2,153	[illegible]	4,[illegible]89	[3]			[3]		[3]		[3]		[3]		[3]		[3]		27[illegible]		8,5[illegible] tons 3,[illegible]51 tons	10[illegible],856 2[illegible] [illegible]3,75[illegible]	Bentonite Pottery clay Borates, brick, calcium chloride, cement, granite, iron ore, lithia, lime, limestone, onyx, mineral water, petroleum, potash, salt, serpentine, tungsten ore, zinc
1939	372,920	128,547	43,133	4,486	6[illegible]	2,932	[3]					[3]		[3]		[3]		[3]		[3]		173,963		8,024 tons	44,0[illegible] 13,[illegible]07,842	Pottery clay Antimony, bentonite, borates, brick, calcium chloride, cement, marble, iron ore, lime, limestone, lithia, mineral water, petroleum, potash, salt, soda, strontium, talc, tungsten ore, zinc.
1940	515,410	153,338	[illegible]6,913	5,753	31,375	1,56[illegible]	[3]					[3]		[3]		[3]		[3]		[3]		174,414		4,7[illegible] tons 7,[illegible] tons [illegible]1,55[illegible] tons	104,612 55,731 174,414 14,5[illegible]	Bentonite Pottery clay Talc Antimony, borates, brick, bromine, calcium chloride, cement, feldspar, granite, lime, limestone, lithia, manganese ore, marble, mineral water, petroleum, potash, quicksilver, salt, soda, strontium, tungsten ore.
1941	593,145	115,835	1,1[illegible]77	13,107	78,991	4,502	[3]			[3]		[3]		[3]		30,003	53,808	[3]		[3]		306,804		10,451 tons 8,241 tons 2[illegible],531 tons	67,961 71,056 263,743 15,371,660	Bentonite Pottery clay Talc Antimony, borates, brick, bromine, calcium chloride, cement, feldspar, granite, iron ore, lime, lithia, manganese ore, mineral paint, mineral water, potash, quicksilver, salt, quartz, soda, strontium, tungsten ore.
Totals	$11,[illegible]63,663	$29,582,660	14,[illegible]83,346	$2,438,5[illegible]7	6,976,832	$460,572	$10,609,295	167,548	$490,166	215,845	$895,186	46,291,465	$76,812,157	925,726	$2,[illegible]39,44[illegible]	1,954,198	$2,250,599	15,909	$125,721	185,3[illegible]	$343,[illegible]76	$9,99[illegible],52[illegible]	$131,[illegible]		$200,3[illegible]1,023	

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[1] Includes crushed rock, rubble, riprap, sand, gravel
[2] Combined annual production 1910, 1911, 1912
[3] See under "Unapportioned"
[4] Reprinted from Division of Mines Bulletin 122, California Mineral Production and Directory of Mineral Producers for 1941, by Henry H. Symons

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By far the most notable development in the county is the plant erected at Fontana by the Henry J. Kaiser Company. This consists of coke ovens, iron blast furnace, steel plant and rolling mills, the first built on the West Coast. The iron ore used in this plant, 2500 tons a day, is mined in eastern San Bernardino County, coal is shipped from Utah, and the limestone comes from Colton only a few miles from Fontana.

Due to increased price there has been an intensive search for tungsten deposits. The Atolia Mining Company built a new mill, the two sections of which (gravity and flotation) have a combined capacity of approximately 500 tons a day. Also at Atolia the Spud Patch Placer is being worked at the rate of 700 to 1000 yards a day with satisfactory results.

Since 1931 [1] the American Potash and Chemical Corporation has doubled the capacity of its plant at Trona, which extracts potash, borax, sodium sulphate, sodium-lithium phosphate, and soda, from the brines of Searles Lake.

The West End Chemical Company also has doubled its capacity and has been in continuous operation producing soda ash and borax from Searles Lake.

In the following pages the mines in the county are described in alphabetical order. Many properties which have had no production and on which no development work has been done since the authors'[1] last report do not appear herein.

Metallic Minerals

Antimony

Desert Antimony Mine. It comprises 3 claims situated in the Clark Mountain district, in sec. 29, T. 16 N., R. 14 E., S. B., about 12 miles southwest of Roach, Nevada, a station on the Union Pacific Railroad; elevation 5000 feet; operator, A. H. Smith, Pasadena, California.

Three parallel veins occur in the granite, strike N. 20° E. Dips vary from 75° W. to vertical. Width of veins varies from 2 to 4 feet. These veins are about 50 feet apart and the main development work has been confined to the West vein. The ore mined is reported to carry 15 to 20 percent antimony and was sorted to carry 40 percent antimony. The ore is stibnite (Sb_2S_3).

On the West vein there is a shaft 100 feet deep with levels at 50 feet and 100 feet; also a tunnel 150 feet in length. Several small shipments of ore were made to the Harshaw Chemical Company, El Segundo, California, in 1939.

Bibl.: State Mineralogist's Report XXVII, pp. 364-365.

Copper

The total value of copper produced in San Bernardino County for the year 1940 amounted to 50,913 pounds of recoverable metal, valued at $5,763. The production for the year 1941 was 111,074 pounds, valued at $13,107, and for 1942 it was 107,195 pounds, valued at $12,971. The average price of copper for 1940 was 11.3 cents per pound, and for 1941, 11.77 cents per pound. The Metals Reserve Company has announced that it will pay, for a period of 2½ years beginning February 1, 1942, and ending July 31, 1944, premium prices for the production of copper in excess of quotas to be established jointly by the War Production Board and the Office of Price Administration. These premium prices will be based on 17 cents for copper. The premium prices paid by the Metals Reserve Company for new production of copper have increased activity in the opening of old copper properties in the county, and there should be an increase in the production of copper during 1943.

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[1] Tucker, W. B., and Sampson, R. J., San Bernardino County: California Div. Mines Rept. 27, pp. 262-401, 1931.

Copper deposits are widely distributed throughout the mountain ranges of the desert area of the county. Practically all production of copper has been from the Ord Mountain district near Daggett, and the Stedman district, south of Ludlow, in the shipment of siliceous ores, which carry values in copper and gold, to the smelters in Arizona. The districts that have produced the largest tonnage of copper ores in the past are: Ivanpah, Ord Mountain, Stedman, Ibex, Old Dad Mountain, Mescal, Signal, Silver Mountain, and the Whipple Mountains. The largest single producers have been the Copper World mine in the Ivanpah district, Bagdad-Chase mines in the Stedman district, Ord Mountain mine in the Ord Mountain district, Vontrigger mine in the Signal district, and the Vulcan mine in Ship Mountain near Siam.

Allured Copper Mine comprises 9 claims, in Sec. 9, T. 15 N., R. 14 E., S. B., situated in the Mescal mining district, 12 miles northeast of Cima, a station on the Union Pacific Railroad, and south of the New Trail copper mine. Elevation 4200 feet. Owner Allured Copper Mining Company, M. E. Allured, Jackson, California.

A series of copper-bearing veins occur in limestone near contact of quartz monzonite. The veins strike northward and dip 70° E. The ore is in both the carbonate and sulphide form. Shipments made from the property during 1918 are reported to have carried from 8 to 20 percent copper. Development consists of two shafts, 125 feet deep, with 600 feet of drifts. Idle.

Bibl.: State Mineralogist's Reports XVIII, p. 611; XXVIII, p. 265.

American Eagle Mine. It comprises 10 claims, situated in the Whipple Mountain mining district, in sec. 32, T. 3 N., R. 24 E., S. B., 13 miles north of Vidal. Relocated by John Jarvis, Parker, Arizona. The copper vein occurs in schists; strike northwest; width 6 to 12 feet. The ore is highly siliceous, mineralized with chalcopyrite associated with pyrite. It is reported to carry from 2 to 10 percent copper with values in gold varying from $2.00 to $20.00 per ton. Developed by shaft, 130 feet deep with 600 feet of drifts. Ore shipped is reported to average 6.35 percent copper, $6.00 in gold. Idle.

Bibl.: State Mineralogist's Reports XV, p. 784; XXVII, p. 266; Bull. 50, p. 377.

Black Mountain Mine. It comprises 3 claims situated on the northwest slope of Black Mountain, in Silver Mountain mining district, in Sec. 19, T. 6 N., R. 7 W., S. B. M., 29 miles east of Palmdale, a station on the Southern Pacific Railroad; elevation 3000 feet; owners, Jennie M. Watts and Dan T. Watts, 1119 Knoll Drive, Monterey Park, California. This property in former state reports was described as being located in Los Angeles County but it is just over the boundary line in San Bernardino County.

The country rock is granite, limestone, and quartzite, associated with dense fine-grained garnet rock. The vein occurs along contact of granite and limestone; strike N. 20° W., dip 75° W. Width varies from 12 inches to 18 inches. There are also parallel N. 40° E. fractures in the footwall granite which are mineralized with malachite where they intersect the vein.

Development consists of shallow shafts, open cuts and a series of trenches. On the Ora Granda, a vertical shaft has been sunk on the vein to a depth of 100 feet. At a depth of 90 feet reported to have developed 18 inches of sulphide ore. Samples on the dump show chalcopyrite and bornite. About 600 feet south of this shaft on the Buna Gorda, a shaft has been sunk on contact of granite and limestone to a depth of 30 feet and east of shaft is an open cut exposing the vein, with mineralization on joint planes in the granite. Ore is reported to carry 1.5 to 8 percent copper, with $3.00 in gold and silver. Idle.

Bibl.: State Mineralogist's Reports XXIII, p. 289; XXXIII, p. 175.

Copper Basin mines comprise 8 claims, situated in the Monumental mining district, in the Whipple Mountains, in secs. 3 and 4, T. 2 N., R. 26 E., S. B., 13 miles north of Parker, Arizona. Elevation, 1000 to 1500 feet. Owners, Frank Ewing, and Charles L. Dunbar, Parker, Arizona; under option to E. R. Sandau, Ray C. Glassbrook, and Howard H. Tuerck, Parker, Arizona. In 1921 and 1922, the property was owned and operated by the Copper Basin Consolidated Mines Company; J. S. Curtis, president, of Los Angeles, California. During this period this company did the major part of the development work on the property. On March 21, 1930, the Copper Basin Mining Company shipped 17.91 tons of ore to the American Smelting and Refining Company, Hayden, Arizona. The ore was extracted from the 100-foot vertical shaft. The ore shipped assayed 12.14 percent copper. The Copper Basin Mining Company's eight claims were relocated by J. E. Mennich, Parker, Arizona, and in November 1941 they were deeded to Frank Ewing and Charles Dunbar, of Parker, Arizona. April 12, 1943, Frank Ewing and C. L. Dunbar shipped 53.48 tons of ore from the dump at the incline shaft, which assayed 3.27 percent copper, to the Phelps Dodge Corporation, Clarksdale, Arizona.

The region of the Copper Basin mine was at one time covered by a basalt flow, which has been eroded. Underlying the basalt are rhyolite, quartz-porphyry, and diorite. The quartz-porphyry and diorite occur in wide dikes and cover the entire surface of the claims. The dikes strike north and dip vertically to 45° E. The veins have the same strike and dip as the dikes. Two well-defined zones of mineralization occur in the quartz porphyry. The easterly zone has a width of 5 to 40 feet, and the westerly zone has a width of 5 to 20 feet. The ore occurs as copper carbonate, oxides of copper, and, at a depth of 80 to 100 feet, sulphide ore occurs as chalcopyrite, bornite, and chalcocite, associated with pyrite. The ore developed carries from 3 to 12 percent copper, and a small amount of silver. About 400 feet south of the incline shaft the veins are intersected by a fault which strikes N. 70° E., and dips 70° N. Both the easterly and westerly veins have been displaced 50 to 100 feet to the east. Where the veins intersect the fault there is a well-defined zone of mineralization from 50 to 100 feet in width.

On Copper Basin No. 4 claim an incline shaft was sunk on the east vein to a depth of 300 feet. The vein strikes N. 30° W., and dips 45° E.; width 6 to 8 feet. The footwall is diorite with porphyry hanging wall. Below the collar of the shaft at depth of 90 feet, a drift has been driven south 95 feet. On this level a sulphide orebody has been developed 65 feet in length with an average width of 6 feet. Samples taken are reported to assay 5.2 percent copper. The present water level is 10 feet below the 90-foot level. On Copper Basin No. 6 claim, which is located 600 feet southwest of the 300-foot incline shaft, a vertical shaft has been sunk on the westerly vein which is roughly parallel to the easterly vein to a depth of 100 feet. The vein occurs in diorite and strikes northward, dipping 80° W. Width of the vein is 4 to 8 feet. Ore shipped from the dump assayed 12 percent copper.

Bibl.: State Mineralogist's Reports XVIII, p. 308; XXVII, p. 267.

Copper Gulch mine (Big Butte) comprises 6 claims, situated in the Ibex mining district, a mile north of Ibex mine, and 6 miles west of Needles, in sec. 28 T. 9 N., R. 22 E., S. B. Elevation 1100 feet. Owner, E. F. Russell, Needles, California.

The vein strikes northwestward; dip vertical; in granite. Development consists of two shafts; one reported to be 600 feet in depth, the other 125 feet deep. One car of copper-gold ore was reported shipped from the property in 1913. Idle.

Bibl.: State Mineralogist's Report XV, p. 785.

Copper Strand Mine (Independence). It comprises 9 claims, situated in the Ord Mountain mining district, and is on the east slope of the Fry Mountains, in sec. 9, T. 6 N., R. 3 E., S. B., 22 miles southeast of Daggett. Elevation, 5000 feet. Owners, L. P. Haney, and H. O. Lee, Barstow, California. In 1900 the property was developed by an incline shaft 500 feet in depth, and by a crosscut tunnel driven west 600 feet. Relocated by L. P. Haney in 1928, and has been under development since that date. The Fry Mountains are southwest of the Camp Rock fault. The rocks on the north end of the Fry Mountains consist of a series of interbedded marbles and quartzites with associated garnet and diopside garnet rocks. In the immediate vicinity of the claims dense fine-grained rock occurs as a belt about 150 feet thick, striking parallel to the ridge. The series is intruded by quartz monzonite. The mineralized zone is 300 feet in width; strike N. 40° W., and the veins in this zone have the same general strike, and dip 50° W. The mineralization can be followed along its outcrop for about 4500 feet. On Copper Strand No. 1 claim, the crosscut tunnel, 600 feet in length, cuts through 12 feet of vein material, mineralized with chalcopyrite. The hanging wall is limestone, the footwall porphyry. A shaft was sunk on an inclination of 50 degrees to a depth of 500 feet on this vein. North of these workings two open cuts have been made on the vein, on the footwall side of the mineralized zone. The ore exposed in these cuts is azurite, malachite, associated with chalcopyrite and pyrite. About 50 tons of ore have been extracted from these cuts, reported to assay 6 percent copper, and some silver. A number of other cuts have been made north of these workings along the outcrop, all of which show the same character of ore. Equipment consists of aerial tram, 500 feet in length; 10-ton ore bin; 9-inch by 12-inch Allis Chalmers crusher, and 12-inch by 16-inch rolls, driven by 10 horsepower gas engine. Ore was ground to minus $\frac{3}{8}$-inch size to leaching vats. Leaching vat is 8 feet by 8 feet, 40 feet in length; with three small precipitation tanks, size 4 feet by 8 feet. One man employed.

Copper World Mine. It comprises 4 patented claims, situated in the Clark Mountain mining district, on the southeast slope of Clark Mountain in sec. 1, T. 16 N., R. 13 E., S. B., 3 miles northeast of Valley Wells, and 18 miles northwest of Cima, a station on the Union Pacific

Railroad. Elevation, 5200 feet. Owner, Ivanpah Copper Company, Dr. L. D. Godshall, vice president and manager; under option to S. D. Greenwood, Los Angeles, and Clinton L. Ray, Glendale, California.

The property was operated from May 1916 to May 1919 by the Ivanpah Copper Company, the ore mined being shipped to the company's smelter at Valley Wells. The smelter had a capacity of 100 tons per day. Ore shipped to the smelter is reported to have averaged 4 percent copper. The ore occurs in a broad mineralized zone at the contact of porphyry and limestone, and the copper ores are found in the porphyry for a considerable distance from the contacts. The mineral-bearing zone is about 200 feet wide in places. Veinlets of copper ore occur in the porphyry, mostly brown oxides, with occasional bunches of malachite and azurite; also, occasional bunches of chalcopyrite are found in lower workings of the mine. The ore is generally low grade, said to average 2 percent copper. Development consists of a series of large open cuts. At an elevation of 5180 feet, the main tunnel is driven N. 40° W. 753 feet in limestone; then drifts southwest 100 feet to porphyry-limestone contact. At this point, a winze was sunk on contact to a depth of 75 feet. At bottom of the winze, a crosscut was driven N. 40° E. 40 feet in diorite; cut 15 feet of sulphide ore reported to carry 4 percent copper. On this tunnel level there are over 2000 feet of crosscuts and drifts. About 45 feet in elevation above the main tunnel is a tunnel 600 feet in length. The orebodies worked were from the main tunnel level to the surface. These orebodies were irregular and the richest ore mined was near the contact.

Dewey mine workings are situated on Dewey claim, about 1500 feet southwest of Copper World workings. The vein occurs on contact of diorite porphyry and limestone. The vein strikes N. 40° W., dips 40° to 60° SW.; width 4 to 8 feet. Copper oxides occur in diorite porphyry, associated with chalcopyrite.

Developed by four tunnels driven on the vein at different elevations. Upper tunnel is driven northwest 125 feet and stoped to the surface for a length of 75 feet. About 25 feet in elevation below this tunnel, an open cut and tunnel 50 feet in length on the vein developed 10 feet of sulphide ore. Fifty feet in elevation below this tunnel is a tunnel driven northwest 75 feet in sulphide ore. Ore is stoped for a width of 6 feet to tunnel above. From this tunnel level, a winze is sunk on the vein to lower tunnel, a distance of 84 feet. Lower tunnel is driven in limestone N. 65° W. 180 feet to contact of diorite, then drift northwest 100 feet to winze, 75 feet of which is in sulphide ore; width 6 feet reported to carry 2 percent copper. Ore shoot developed is 75 feet in length, has an average width of 6 feet and extends to intermediate tunnel level, a distance of 84 feet. Ore reserves are 5000 tons of 2 percent copper. When the property was under operation, there was an incline tram from lower tunnel about 500 feet in length to loading platform at road from Copper World mine. The ore was hauled by truck to Valley Wells smelter for treatment in 1918. The Copper Commander group of claims adjoining Copper World group on the northwest has been relocated by the present operators.[2]

The average grade of ore treated at the smelter was 4 percent copper, 3 to 5 ounces in silver and 0.04 to 0.10 ounces in gold. Three men were employed on development work.

Bibl.: State Mineralogist's Reports XIII, p. 61; XV, p. 786; XVII, pp. 339-340; XX, p. 93; XXVII, p. 269; Bull. 50, pp. 326-328.

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[2] Tucker, W. B., Los Angeles Field Division: California Min. Bur. Rept. 20, p. 93, 1924.

Foster Mines. The property comprises 22 claims known as Glory group, situated in Shadow Mountain mining district, in sec. 15, T. 17 N., R. 11 E., S. B., 25 miles east of Silver Lake. Owner, Foster Mines Company, E. D. Foster, president and manager, Los Angeles. A series of parallel veins in porphyry and schist carry copper, gold, and silver. Three shafts have been sunk on the different veins to depths of 100 to 300 feet. Idle.

Francis Copper Mine. The property comprises 6 claims, situated in the Kelso mining district, on the east end of the Providence Mountains, in sec. 7, T. 11 N., R. 14 E., S. B., 4 miles southeast of Dawes, a station on the Union Pacific Railroad. Elevation, 4350 feet. Owner, Francis Copper Mining Company; C. Colcock Jones, president, 102 South Occidental Boulevard, Los Angeles; under option to Charles L. Nichols and Hugh B. Martin, 811 West 7th Street, Los Angeles.

The principal development has been confined to the Cuyamaca vein which strikes northeastward, dips 70° NW., and has a width of 6 to 30 feet. The vein occurs in gneissic-schistose formation. The ore is copper, lead, and zinc sulphides, carrying silver in quartz gangue. The Cuyamaca vein can be traced along its surface outcrop for a distance of 2500 feet. The Francis mine on the Cuyamaca claim is developed by two shafts to depths of 70 to 140 feet, with a connecting drift on the 70-foot level, 160 feet in length, and other drifts on the 140-foot level, totaling 600 feet. The Ivanpah Copper Company, Dr. L. D. Godshall, manager, operated the property in 1917-1918, shipping 307 tons of copper-silver ore to the Valley Wells smelter, which averaged from 1.7 to 2 percent copper and 7.8 ounces to 10.6 ounces in silver, without taking into account the lead and zinc content. The ore contains from 1 to 2 percent lead, and from 3 to 10 percent zinc. The present operators have received a preliminary development loan from the Reconstruction Finance Corporation to unwater the mine, and retimber the workings.

Bibl.: State Mineralogist's Reports XVII, p. 341; XXVII, pp. 271-272.

Giant Ledge Gold and Copper mine comprises 4 patented claims: Hard Case, Athens, Morning Star, and Miami, situated in Ivanpah mining district, in the New York Mountains, in sec. 31, T. 14 N., R. 16 E., S. B., 6 miles south of Ivanpah, a station on the Union Pacific Railroad. Elevation, 5700 feet. Owner, Earl Stuart Rhode, Los Angeles. The property is located west of the Sagamore mine. The vein occurs as a massive outcrop of quartz up to 60 feet in width; strike northeast, dip vertical. Development consists of cross cut tunnel 700 feet in length, and shallow shafts and open cuts along the outcrop. The vein quartz is heavily stained with copper oxides. Idle.

Bibl.: State Mineralogist's Reports XV, p. 786; XXVII, p. 272; Bull. 50, p. 333.

Gold Banner mine comprises 9 claims, situated in Ord Mountain mining district, adjoining Ord Mountain mine, in sec. 12, T. 7 N., R. 1 E., S. B., 15 miles south of Daggett; elevation 5000 feet; owner, Dr. W. M. Smith, Daggett, California; under option to Ray T. Savage, Barstow, California.

A series of parallel veins occur in andesite, strike N. 5° E. and dip 50° to 70° E. The width of the veins varies from 4 to 20 feet; average width 4 feet. The mineralization consists of copper carbonates, chalcopyrite and bornite, carrying gold. The ore is reported to carry 3 to 7 percent copper, and $3.00 to $4.00 in gold. Development consists of two tunnels 600 feet in length and three shafts, each 60 feet in depth. Equipment consists of two portable compressors and air drills. Three men are employed.

Nellie May Group of Copper Claims. It comprises 4 claims situated in sec. 2, T. 7 N., R. 7 W., S. B., 11 miles east of Hivista and 28 miles east of Lancaster; elevation 3700 feet; owners, W. H. Duvall and R. W. Klages, Los Angeles.

A series of roughly parallel veins occurs in granite near contact of siliceous limestone. The veins in places are capped with iron gossan. They strike north, dip 40° E. The veins are from 12 inches to 2 feet in width. Development consists of a number of shafts and open cuts from 10 to 30 feet in depth. It is reported that samples taken from different veins carry 2 to 3 percent copper, with 7 ounces in silver and $3.00 in gold. Two men are employed on development work.

New Trail mine, comprises 28 claims, is located on the east slope of the Ivanpah Mountains, 11 miles north of Cima, a station on the Union Pacific Railroad, in sec. 4, T. 15 N., R. 14 E., S. B.; elevation 5000 feet; owner, New Trail Mining Company, J. F. Kent, president, Box 867, Riverside, California; Joseph L. Johnson, vice president; J. D. Loop, secretary, Cima, California.

The country rock on this property is limestone; strike N. 30° W., dip 45° NE., between granite walls. The limestone has been intruded by dikes of monzonite and has been faulted along a northeast-trending line with a throw of several hundred feet. The ore has formed along a series of northwest-trending fractures and in the adjacent bedding planes, between the faulted segments of a garnet-epidote dike, which strikes N. 40° E., dips 80° NW. The dip of the ore-bearing fractures is approximately 50° SW.

Since 1931 [3] the company has sunk the main shaft 80 feet and drifted southwest 200 feet at the bottom (280-foot) level. A raise from this level was put up 42 feet to connect with winze from the 200-foot level. Material from this raise is said to have carried $26.00 to $30.00 in gold and silver and 5 to 6 percent copper. Shipments from the property have amounted to more than $100,000.00, averaging 0.207 ounces of gold, 8.0 ounces of silver, and 14.26 percent copper. Idle at present.

The property is fully described in State Mineralogist's Report XXVII, pp. 275-276.

Ord Mountain mine (Osborn group), comprising 22 claims, 17 of which are patented, is in the Ord Mountain district, secs. 12, 13, 24, T. 7 N., R. 1 E., S. B., 13 miles south of Daggett. Elevation, from 4000 feet to 5500 feet. Owner, Harvey J. Stevenson, 510 South Spring Street, Los Angeles; leased to Symons Bros. Development Company, 1001 North Orange Drive, Los Angeles.

The lessee shipped eight cars of ore from the Rio Vista workings; four of these came from a raise put up 80 feet from the sub-level above the middle tunnel, the others from old workings of the sub-level and intermediate level.

It was then determined to move to the Coupon claim where a crosscut was driven west for 300 feet, in the hope of finding the junction of the Coupon and Josephine veins. Apparently, ore of a commercial grade was not here encountered and it is reported that the lessee is abandoning the project. A modern camp to accommodate some 30 men was erected and considerable road work was done.

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[3] Tucker, W. B., and Sampson, R. J., op. cit.

A full description of this property will be found in State Mineralogist's Report XXVII, pp. 276-278.

Revenue Copper Mine. It comprises 4 claims, situated in the Bullion mining district, on the east slope of the Ivanpah Mountains, adjoining the New Trail mine on the northeast, in sec. 4, T. 15 N., R. 14 E., S. B., 12 miles northwest of Cima, a station on the Union Pacific Railroad. Elevation, 5600 feet. Owner, Joseph L. Johnson, Cima, California; under lease and option to J. W. Bruce, Charles Hale, L. H. Cox, and E. L. Josephson, Las Vegas, Nevada. The country rock is limestone; strike N. 30° W., dip 45° NE., between granite walls. The vein occurs along a porphyry intrusion in the limestone; strike, N. 30° E., dip 80° NW.; width 4 to 6 feet. The ore is copper carbonates and oxides, bornite and chalcopyrite. Development consists of a shaft sunk on the vein to a depth of 70 feet, also a crosscut tunnel driven N. 30° W. for 100 feet, intersecting the shaft 20 feet below collar. On the 70-foot level there is a drift S. 35° W., 40 feet on the vein; a small amount of stoping on the 40-foot and 70-foot levels; workings caved. The property was under lease to Harrington and Cox, Cima, California, from 1917 to January 1919. They shipped 4 cars of ore, reported to have had an average of 25 percent copper, and $7.00 per ton in gold and silver. Smelter returns of ore shipped are as follows: Gold 0.12 to 0.16 ounces, silver 3.87 to 4.54 ounces, copper 25.02 to 26.50 percent, insoluble 11.8 to 28.50 percent, iron 16.0 to 21.0 percent. Four men are employed in building a road from the New Trail mine to the Revenue shaft. Equipment consists of a caterpillar tractor, and a 110-cubic foot compressor.

Riverview mine (Tuscorora) comprises 5 claims, situated in the Whipple Mountains, in sec. 1, T. 1 N., R. 24 E., S. B., 9 miles northwest of Parker, Arizona, and 7 miles northwest of Earp, a station on the Santa Fe Railroad. Elevation, 1200 to 1500 feet. Owner, John Jarvis, Parker, Arizona.

Two vein systems occur in granitic schist and limestone; one series strikes east, the other or main vein occurs on contact of limestone and schist. Vein-filling of the latter is quartz-porphyry. This latter vein strikes northeast, dips 35° NW.; is 4 to 8 feet wide, has 2 feet of talc on the limestone hanging wall, and a schist footwall. Ore is copper oxides and carbonates, carrying from 3 to 6 percent copper, with $10.00 in gold per ton.

The main shaft is sunk on the northeast-trending vein to a depth of 200 feet, with a drift 30 feet northeast on the 125-foot level. On the 150-foot level there is a drift 50 feet northeast. West of the main shaft a tunnel has been driven 180 feet in length on the east-trending vein. Two hundred tons of ore shipped from the property is reported to have averaged 3.82 percent copper, and $12.12 in gold per ton. Idle.

Bibl.: State Mineralogist's Reports XV, p. 791; XXVII, p. 280.

Sagamoré mine (New York), comprising 8 patented claims and 24 held by location, in sec. 35, T. 14 N., R. 16 E., S. B., is on the south slope of the New York Mountains, about 17 miles south of Ivanpah. Elevation, 6300 feet to 7500 feet. Owner, Ivanpah Copper Company, Dr. L. D.

Godshall, 722 South Oxford, Los Angeles; under lease to California Sulphur Company, J. C. Baldwin, president, 1427 East Fourth Street, Los Angeles; subleased to El Dorado Rover Mining Company.

The rocks exposed on the property consist of quartzite, crystalline limestone, rhyolite, and granite. At both the east end and west end of the property there is a large body of limestone. These are separated by about 5000 feet, in which the other rocks occur. Four roughly parallel veins have been discovered on the property. They strike east and dip about 80° N. The principal one is from 4 feet to 14 feet wide. It outcrops boldly across the 5000 feet between limestone bodies, often rising above the surface 15 feet to 25 feet. It also traverses the limestone at each end of the property. The vein filling is quartz. The ore contains lead, silver, zinc, copper, and tungsten, in the form of galena, sphalerite, chalcopyrite, and hubnerite.

The property has been developed by several open cuts and at the west end on the Alpha Lode #4 there are two tunnels driven west, the upper for 600 feet, the lower, 80 feet below, for 1000 feet. At 570 feet from the portal of the lower tunnel is a shaft sunk from the surface. The lessees cleaned out some 560 feet of the lower tunnel and drifted around the cave at the shaft, opening the tunnel for approximately 775 feet, where more caved ground was encountered. A shoot of lead-zinc-copper ore was found, about 100 feet west of the shaft which continued to the shaft. Its width varied from about 4 feet to 14 feet. Samples of this ore were reported to range from 5 to 50 percent lead, 3 to 25 percent zinc, with an undetermined copper content. This work was abandoned at about 200 feet beyond the shaft. An attempt was then made to develop a commercial body of tungsten ore across the gulch east of these tunnels. Apparently, this was not successful and work on the property has been suspended.

Bibl.: State Mineralogist's Reports XV, p. 790; XXVII, p. 279; Bull. 50, pp. 331-332.

Trio group, consisting of 7 patented claims, the Copper Bullion, Dot, Nugget, Scorpion, Side Issue, Sophie Metcalf and William C, is in the Vanderbilt mining district, in secs. 21 and 22, T. 14 N., R. 16 E., in the New York Mountains, a mile west of Barnwell and about 6 miles southeast of Ivanpah, a station on the Union Pacific Railroad; elevation about 4800 feet; owner, Henry Lias, Ivanpah, California.

A deposit of crystalline limestone about 1000 feet wide traverses this area in a northerly direction for about 5 miles. The property is at the south end of this belt. Here east-trending fractures in the limestone dip steeply northward. These fractures are as much as 2 or 2½ feet wide and are filled with iron-stained altered wall rock. Short lenses of copper ore have formed at irregular intervals along the fractures. The copper minerals are bornite and chalcopyrite.

Development consists of a vertical shaft on the Copper Bullion claim said to be 300 feet deep. It is now partially filled, and was inaccessible at time of visit. Some 400 feet west and about 100 feet north of this shaft, a tunnel has been driven east about 150 feet. At the portal of this tunnel a lens of ore about 2 feet wide, 30 feet long, and 15 feet high has been removed. Two or three similar lenses were encountered in the tunnel. These workings together with a few shallow open cuts constitute the development to date. It is probable that about 100 tons of good grade ore could be cobbed from the dumps. Idle.

Vontrigger copper mine (California gold and copper mine) comprises 9 patented claims, situated in the Signal mining district, New York Mountains, in secs. 10, 11, and 15, T. 11 N., R. 17 E., S. B., 10 miles north of Goffs, a station on the Santa Fe Railroad; elevation 3700 feet; owner, Guy L. Goodwin, Long Beach, California; under lease to H. C. Mills, 718 South Union Street, Los Angeles. The property was operated by the California Gold and Copper Company, Lionel Brooke, president and manager, from 1926 to 1929. The production amounted to 3500 tons of copper ore, reported to have averaged 5 percent copper.

Two veins occur in granite and schist. One is the Goodwin vein, strike N. 45° E., dip 85° NW., width 6 to 20 feet; the other is the Medberry vein, strike N. 25° E., dip 55° NW., width 8 to 20 feet. The Medberry vein is 485 feet northwest of the Goodwin vein. The ore is chalcopyrite associated with pyrite, assaying 4 to 7 percent copper, and $1.00 to $2.00 per ton in gold. Development consists of 3 shafts; two on Goodwin vein, 100 and 317 feet in depth respectively, and the Medberry incline shaft sunk on the Medberry vein to a depth of 200 feet. Present development is confined to the Medberry shaft. On the 82-foot level there is a drift 60 feet northeast; on the 140-foot level, a drift 150 feet southwest; on 82-foot level, a stope 50 feet in length, 40 feet in height, and 20 feet wide.

Mine equipment consists of 15-horsepower Fairbanks-Morse single drum hoist, portable compressor, capacity 150 cubic feet. Six men are employed retimbering the shaft.

Bibl.: State Mineralogist's Reports XV, p. 785; XXVII, p. 267.

Gold

Gold is the most widely distributed metal of commercial value in San Bernardino County. It was discovered in the San Bernardino Mountains in May 1860. From 1860 to 1880, production was not recorded, but from 1880 through 1940, value of gold produced was $10,500,518.

Within the boundaries of the county there are numerous gold prospects, as well as developed mines which have produced in the past. In December 1942 gold mines throughout the United States were shut down by Order L-208 issued by the War Production Board. The purpose of this order was to make gold miners available for work in strategic metal mines. Its effect on the industry in San Bernardino County was the closing of all gold mines but one. This property, the Bagdad-Chase mine, south of Ludlow, was allowed to continue its operations by reason of the fact that they are shipping to Arizona smelters a highly siliceous ore which is essential in the smelting of copper.

In the following pages only those gold properties which have produced, or have had a notable amount of development work, or have been discovered since 1931 are described. For other gold properties in the county refer to the report of 1931.[4]

Alvord mine. It comprises 6 patented claims and one mill site situated in secs. 1, 2, and 12, T. 11 N., R. 3 E., S. B., in the Alvord Mountains, 6 miles northeast of Manix and 14 miles northeast of Yermo, a station on the Union Pacific Railroad; elevation 2500 feet; owner, Dellosso Gold Mining Company, F. G. Dellosso, president, Huntington Park, California. The property was located in 1885 and operated until 1891 by the Carter Gold Mining Company, of Pasadena, California, J. McLore, president.

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[4] Tucker, W. B., and Sampson, R. J., op. cit.

The ore mined was treated in a 5-stamp mill at Camp Cady on the Mojave River. It is reported that they recovered $12.75 per ton by amalgamation with a loss of $1.25 per ton in the tailings. The total production during this period of operation was $50,000.

The property was operated from 1906 to 1910 by Alvord Gold Mining Company, of San Diego, California. This company installed a 6-Nisson stamp mill. From 1916 to 1920, the Tintic Bonanza Mining Company, of Salt Lake City, Utah, Gidion Snyder, president, operated the property. F. G. Dellosso purchased the property in 1925 and formed the Dellosso Mining Company and patented 6 claims in 1931.

The claims are located along a broad belt of crystalline limestone. A dike of porphyritic rock cuts across this belt of limestone at an angle of about 90°. The principal mineralization occurs east of this dike. The rock is more or less schistose in character. Through it, at frequent intervals, are intruded eruptive dikes. At the east end of the belt is an accumulation of tufa and basalt. The belt strikes eastward, dips 75° S.

The mineralized portion of this lode extends from the porphyry dike east through three full claims and disappears finally beneath the eruptive rocks. The entire lode is gold-bearing, some of the hematite and jasper rock being rich. Gold also occurs in the calcite, though usually lower grade than where accompanied with iron. Iron sulphides also are found carrying gold. The ore mined was limonite and jasper, showing some copper stains.

Development on Royal claim consists of glory hole 150 feet in length and 140 feet wide. This orebody dips 70° S. The glory hole is 200 feet in elevation above lower tunnel and 100 feet above upper tunnel. The upper tunnel is driven east 500 feet on fissure in limestone. Orebody developed on this tunnel level was 100 feet in length and 6 feet to 12 feet in width; stoped from tunnel level to 40 feet of surface outcrop. The lower tunnel is driven east 550 feet in the footwall limestone. At 100 feet east of the portal, a crosscut was driven south 100 feet along contact of granite and limestone. At 150 feet east of portal, intersected orebody exposed in upper tunnel. Equipment consists of C. P. compressor driven by 15-horsepower Fairbanks-Morse gas engine. Mill equipment consists of 9-inch by 15-inch Blake type crusher; 6 Nisson stamps; amalgamation plates; and cyanide tanks.

Water is secured from well 500 feet deep, with a capacity of 5000 gallons per 24 hours, 1½ miles southwest of mine. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 499; XI, p. 359; XIII, p. 319; XXVII, p. 281; XXXVI, pp. 53-54.

Amargosa Gold Placers (Sharps Diggings). The property is known as the Reguam and Howe group of placer claims and consists of the following sections: 11, 14, 23, 24 and 25, T. 19 N., R. 4 E., S. B., 50 miles north of Baker and 22 miles northwest of Silver Lake. The claims are located on the Amargosa River, covering 5 miles along the river; elevation 356 feet; owner, Harry D. Mauger, Burbank, California, and Frank G. Howe, Los Angeles.

The gold occurs in a very fine state in unconsolidated sands and gravel. Depth of gravel is about 40 feet. Bedrock is shale and limestone. In 1932 and 1933 the property was under option to H. F. Alexander Exploration Company. This company prospected the area with shafts and drill holes and it is reported the average value of the gravel was 55 cents per cubic yard, on a basis of assays from 1500 samples. Tests to determine the method of treatment were made but it is stated that due to the fine character of the gold, associated with heavy black sands, no satisfactory method of recovery of the gold was made. Idle.

American Mine. It comprises 4 patented claims situated in sec. 19, T. 4 N., R. 12 E., S. B., on the north slope of the Sheep Hole Mountains, 10 miles south of Amboy, a station on the Santa Fe Railroad; elevation 3600 feet; owner, Marcus Pluth Estate, Daggett, California; under lease and bond to American Mines, Inc., F. H. Merrill, president and manager; George Nilsson, secretary; Paul E. Fuller, superintendent, 908 Richfield Building, Los Angeles.

The country rock is rhyolite and andesite. Mineralization occurs in fine-grained rhyolitic porphyry dike. The ore occurs in fractures and seams in the rhyolite, the gold occurring free and associated with hematite; also small amounts of arsenopyrite and chalcopyrite. The orebody strikes east, dips 25° N. and is from 60 feet to 150 feet in width and about 600 feet in length along the strike.

Development consists of a tunnel driven S. 30° E. for 400 feet, then drift northeast 60 feet to north-trending fault, with drift north along fault 100 feet. At 300 feet from portal, the tunnel intersects shaft sunk on orebody from surface. The shaft is 120 feet in depth. There is a drift driven southwest 260 feet from shaft. All workings on tunnel level are in trachyte. Upper tunnel is driven south 200 feet, and 150 feet from portal, drift west 150 feet to shaft.

Mine equipment consists of 120-horsepower Fairbanks-Morse diesel engine and Ingersoll-Rand compressor. Mill equipment consists of crusher, rolls, rod mill and sand-leaching cyanide plant, with a capacity of 50 tons. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 54-55.

Arlington Mine: see Santa Fe Mines.

Bagdad-Chase Mines (Pacific Mines). The property comprises 17 patented claims, totaling 340 acres, situated in the Stedman district, in secs. 7 and 8, T. 6 N., R. 8 E., S. B., 7 miles south of Ludlow, a station on the Santa Fe Railroad. Owner, John H. Hobbs, Glendora, California; under lease to Frank Royer, Red Mountain, and Don L. Love, Ludlow, California.

The ore is deposited in igneous breccia on a contact of monzonite and rhyolite. The brecciated material, which is the result of faulting, consists of both rhyolite and monzonite fragments cemented with highly siliceous material. The mineralized zone strikes eastward, dips 25° to 30° N., and has an average width of 8 to 20 feet. The ore is very siliceous, being heavily stained with iron oxides and some copper oxides and silicates. The principal value is in gold with a copper content of less than 1 percent. Since the early part of 1940, the shipments to the American Smelting and Refining Company's smelter at Hayden, Arizona, have been 40,000 tons of siliceous gold ore stated to carry $9.30 per ton in gold; copper, 0.80 percent; and silica, 80 percent. Present shipments amount to 200 tons of ore per week. Development consists of three shafts: a vertical shaft, 400 feet deep; another vertical shaft, 125 feet in depth; and an incline shaft, 450 feet in depth. The present operations, confined to the 125-foot vertical shaft east of the main vertical shaft (400 feet), consist of stoping ore from the 90-foot level to the surface glory hole. The present operators have developed ore in the footwall of the vein originally worked by the former operators on the 60- and 90-foot levels. The orebody developed from the 90-foot level to the glory hole is 300 feet in length, and 18 feet in width. It is reported to contain 30,000 tons of commercial ore. Mine equipment consists of 25-horsepower hoist; one Ingersoll-Rand compressor, capacity 320 cubic feet; one Worthington compressor, capacity 320 cubic feet; air drills, and a 5-ton truck. Seven to fourteen men are employed.

Bibl.: State Mineralogist's Reports XV, p. 790; XVII, pp. 341-342; XXVII, pp. 278-279; XXXVI, pp. 56-57, pp. 232-233.

Belmont Mine. It comprises 5 claims situated in the Goldstone mining district, 34 miles northeast of Barstow, in sec. 35, T. 14 N., R. 1 E., S. B.; elevation 3500 feet; owner, Belmont Mining Company, Dr. W. W. Ramsey, president, Stockton, California; under lease to W. E. Bailey and Arthur Beale, Goldstone, California.

Two parallel quartz veins occur in shales and schist, strike N. 60° W. and dip 25° NE.; width 12 inches to 3 feet. The main shaft is sunk on the footwall vein to a depth of 400 feet, with levels at 100, 160, 230, 330 feet, and about 1000 feet of drifts and crosscuts. Ore mined is said to carry from $8 to $20 per ton in gold.

Mine equipment consists of 25-horsepower hoist, Chicago Pneumatic compressor and blacksmith shop. They recently installed a 25-ton amalgamation and concentration plant.

Mill has a capacity of 25 tons; amalgamation and flotation; crusher, ball mill, Dorr classifier, amalgamation plates, Groch flotation cell.

Mill run of ore is stated to average $14 per ton in gold. Idle.

Bibl.: State Mineralogist's Reports XX, pp. 46-47; XXVII, pp. 287-288; XXXVI, p. 57.

Big Four Mine (Red Bridge). It comprises 10 claims situated in Goldstone mining district, 34 miles north of Barstow, in sec. 19, T. 14 N., R. 1 E., S. B.; elevation 3500 feet; owner, W. B. Redfield Estate, Goldstone, California; under lease to W. A. Fritz, Long Beach, California.

The mineralized zone is about 1200 feet in width and about a mile in length. The shale and schist in this zone are cut by numerous quartz stringers and veins of quartz carrying gold. The general strike of the zone is northwest, the dip 25° NE. The sedimentary rocks are cut by diorite dikes, roughly parallel, with a northwest strike.

Development consists of 5 shafts 50 feet to 125 feet in depth and an open cut 50 feet in length by 20 feet in width. The vein quartz and stringers mined are reported to carry from $20 to $200 per ton in gold. A number of trenches have been made across the mineralized zone to determine the average grade of ore. Idle.

Bibl.: State Mineralogist's Report XV, p. 807; XXXVI, p. 57.

Big Horn Mine (Mabel-Contention). It comprises 18 claims situated on the east slope of the Providence Mountains, 23 miles west of Essex, in sec. 20, T. 9 N., R. 14 E., S. B.; elevation 3750 feet; owner, Big Horn Exploration Company, Watsonville, California, F. H. Wagenheim, superintendent, Essex, California.

The formation is principally quartz monzonite, diorite, quartzite and andesite. A series of parallel intrusive dikes of andesite cut quartz

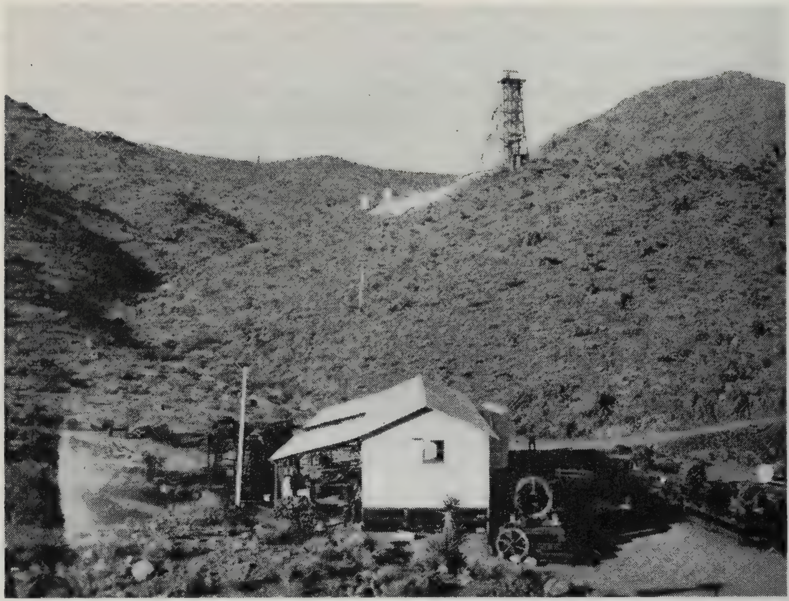

FIG. 1. Head-frame and machine shop, Big Horn mine, Arrow mining district, Providence Mountains.

monzonite. The dikes have a northward trend. The quartz veins occur on both walls of these dikes. The veins vary in width from a few inches to 4 feet; strike N. 20° E. and dip 40° to 75° W. The ore is siliceous in character and contains gold, silver, and copper.

The principal development work has been confined to the Contention and Mabel claims. On the Contention claim a 3-compartment vertical shaft has been sunk to a depth of 325 feet, with levels at 160 feet and 300 feet. On the 160-foot level, there is a drift south 440 feet to Subway shaft on Subway vein. The Subway vein is west of the andesite dike; strike N. 20° E., dip 65° W.; width 8 inches to 12 inches. Vein quartz is mineralized with pyrite and chalcopyrite, and gold. About 68 feet south of shaft, cut east-trending vein which dips 50° S. has a width of 10 feet. On 300-foot level, there is a drift south 110 feet to east-trending vein and crosscut from shaft is driven northeast 110 feet with about 100 feet additional to drive to intersect Contention vein.

On the Mabel claim a shaft has been sunk on the vein to a depth of 140 feet, with 80 feet of drifts on the 140-foot level. Width of vein is 4 feet. At a depth of 40 feet from collar of the shaft, sulphide ore was encountered.

Equipment includes power plant, consisting of 240-horsepower, 4-cylinder, Fairbanks-Morse diesel engine, direct connected, with 200 K. V. A. generator; Imperial Type No. 10 Ingersoll-Rand compressor, capacity 550 cubic feet, driven by 100-horsepower motor; two 55,000-gallon tanks for water storage; one 30,000-gallon tank for oil storage.

Mine equipment consists of 80-foot headframe, with ore bins; 25-horsepower hoist; complete machine shop. Idle.

Bibl.: State Mineralogist's Reports XV, p. 801; XVII, p. 349; XX, pp. 196-198; XXVII, pp. 303-304; XXXVI, p. 58.

Blue Eagle Mine. It comprises 8 claims, situated on the north slope of the Old Woman Mountains, in Danby mining district, in sec. 19, T. 6 N., R. 17 E., S. B., 6½ miles southeast of Danby, a station on the Santa Fe Railroad; elevation 2900 feet; owners, Nicholas C. Aldo and W. Baldwin, Hollywood, California.

Three parallel veins occur in granite about 200 feet apart, strike N. 30° W., dip 80° E.; width 12 inches to 2 feet. Vein quartz carries free gold associated with iron pyrite, arsenopyrite, galena, and sphalerite.

Development consists of a shaft sunk on West vein to a depth of 160 feet. About 1000 feet north of this shaft, another shaft has been sunk on vein to a depth of 50 feet. Selected ore shipped to Burton Bros., Inc., at Rosamond, California, is reported to have had an assay value of $50.00 per ton. At present ore is being mined from Florence vein from open cuts along outcrop for a distance of 500 feet. These workings are about 1000 feet south of No. 1 shaft.

Equipment consists of 6-horsepower hoist and portable Ingersoll-Rand compressor, capacity 260 cubic feet. Ore is hauled by truck to mill, with a capacity of 20 tons per 24 hours; 6-inch by 8-inch crusher, to rolls and ground to ⅛-inch size; then to ore bin; ore from bin to Herman ball mill where it is ground to 40 mesh; then over amalgamation plates (4 feet wide by 8 feet long); overflow from plates to Plato concentrator. Mill is driven by 40-horsepower Holt gas engine. Concentrates produced are reported to carry $200 to $300 per ton in gold. Water for mill is pumped from No. 1 shaft to storage tank, then flows by gravity through 2-inch pipeline 900 feet long to mill. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 58-59.

Bullion Range Company, Inc., Roger Dering, president, Ludlow, California, did considerable development work on 19 claims in sec. 7, T. 6 N., R. 8 E., S. B., 9 miles south of Ludlow and adjoining the Bagdad-Chase mine on the west.

The country rock on this property is rhyolite and monzonite. The contact strikes N. 25° W., dips about 65° NE. The ore forms in the brecciated zone along the contact. The breccia which has been recemented with quartz is said to average 12 feet in width.

Development consists of a shaft sunk on 32° inclination for 120 feet. On 100-foot level, drifted N. 25° W. 200 feet on barren contact. At 60 feet from the shaft sunk winze 102 feet and drifted 80 feet southeast at the bottom, northwest 125 feet. At 85 feet from winze in the northwest drift, sunk another 130 feet. No continuous ore shoots were encountered and work was discontinued.

Bibl.: State Mineralogist's Report XXXVI, p. 233.

Camp Rock Mine (placer). It consists of 3 lode claims and 9 placer claims in sec. 28, T. 7 N., R. 3 E., S. B., in the Bessemer Mountains, 25 miles northeast of Box S Ranch and 47 miles (by road) from Victorville; owner, S. H. Clinedinst, Pasadena, California. Elevation is 4500 feet.

The claims lie on the detrital slope at the foot of the southwest side of the Bessemer Mountains. The drainage is to the southwest into the valley which also receives the drainage from the southwest slope of the Ord Mountains. A narrow drainage channel on this slope has been prospected for about 1000 feet. The work consists of shallow pits and open cuts. The general course of channel is northeast, its width being about 600 feet, with depth of gravel varying from 2 feet to 25 feet.

Bedrock is granite. Values range from 25 cents to $1.25 per cubic yard. The deposit has been worked by dry washers previous to 1932. In 1932, a washing and screening plant was installed on the property and operated until September 1933. Water for operating this plant was secured from two wells located a quarter of a mile west of the deposit. One well has a depth of 200 feet, the other 250 feet. Idle.

Bibl.: State Mineralogist's Reports XXVII, p. 291; XXXVI, 233.

Carlyle Mine. The property comprises 4 patented claims and 4 claims held by location, located in sec. 11, T. 1 S., R. 12 E., S. B., in the Dale mining district, on the northeast slope of the Dale Mountains, 7 miles northeast of New Dale and 23 miles southeast of Twenty-nine Palms; elevation 2500 to 3000 feet; owner, Carlyle Mining Corporation, George C. Dorman, president; A. E. Cates, secretary, 202 Quinby Building, Los Angeles. The property is under lease and bond to Camco Mining Company, R. M. Campbell, president and manager, Twenty-nine Palms, California.

The Carlyle Mining Corporation operated the property from June 1936, to March 1938, during which period it mined and milled 13,256 tons of ore, recovering $124,000. Camco Mining Company started operations April 15, 1939.

The vein occurs in a fault fissure, having a diorite footwall, and granodiorite hanging wall. The vein strikes N. 15° E. and dips 75° W.; width 6 feet to 12 feet. Gold occurs in a fine state associated with silver chloride, lead carbonate, and galena. Silver minerals in the ore are pyrargyrite, polybasite, and stephanite. Lead minerals are galena, anglesite, and cerussite.

Development consists of lower tunnel driven south 1500 feet in quartz diorite. No ore developed and the tunnel is driven parallel to vein developed in upper workings. About 330 feet in elevation above lower tunnel, the main working tunnel is driven south 1200 feet on the vein. Five ore shoots were developed on this level. These ore shoots are 50 feet to 150 feet in length, with 200 feet of backs. First ore shoot was intersected 600 feet south of portal of tunnel. The ore shoot is 100 feet in length, with average width of 6 feet; stoped to surface. At 680 feet south of portal, a winze is sunk on the vein to a depth of 330 feet. At 580 feet south of portal, there is a raise put up on vein to the surface, a distance of 200 feet; at 480 feet, raise up 150 feet to surface. At 680 feet from portal of tunnel winze workings below tunnel level. There are levels at 30 feet and 80 feet. On the 30-foot level drift 200 feet on vein; on 80-foot level drift 350 feet. Ore shoot developed on these levels is 60 feet in length, 6 feet in width; there is high-grade silver ore on footwall and gold ore on hanging wall. The gold ore is reported to average $12.00 per ton.

Mine equipment consists of Chicago Pneumatic Hot Head compressor with a capacity of 500 cubic feet, located in mill. Air line from mill to mine consists of 2-inch pipeline 3000 feet in length; blacksmith shop and air drills.

Mill: Mine run of ore from upper tunnel is trammed in 1-ton cars to ore bin with a capacity of 70 tons. From this ore bin, the ore is transported by aerial tram 2680 feet in length, equipped with 2 buckets, each having a capacity of 1500 pounds. The tram is driven by 30-horsepower motor. Ore is dumped into coarse-ore bin with a capacity of 60 tons. Ore from bin goes to No. 5 Kennedy gyratory crusher where it is crushed to 1-inch size. From gyratory crusher, ore is conveyed by 14-inch belt conveyor to 80-ton fine-ore bin. Ore goes from fine-ore bin by 16-inch belt feeder to 5½-foot by 6-foot Traylor ball mill, in closed circuit with 5-foot by 22-foot Dorr duplex classifier, with Pan American jig between ball mill discharge and classifier to recover coarse gold. Ore is ground to minus 100 mesh; overflow from Dorr classifier to 6-cell Kraut rougher cells; the concentrates from rougher cells to 2-cell Kraut cleaner cells; the tailings from 6 rougher cells to 2 Kraut scavenger cells; concentrates from cleaner cells to 3-foot by 4-foot Oliver filter. The concentrates recovered on scavenger cells are returned to rougher cells. Tailings from scavenger cells to Deister table cut a concentrate from table carrying iron and lead which carries $40.00 to $60.00 in gold and silver. This concentrate is shipped separately. Flotation concentrate from cleaner cells is reported to carry $800.00 to $1000.00 per ton. Ratio of concentration is 200 to 1. Heads carry from $10.00 to $20.00 per ton in gold, with $3.00 to $6.00 per ton in silver. Tailings from mill flow by launder to 8-foot by 20-foot Dorr thickener. Power to drive mill consists of 225-horsepower Fairbanks-Morse 3-cylinder diesel, direct connected to 150 K.V.A. General Electric generator. Water supply is from well 135 feet deep; 8-inch casing. Water is pumped by Ingersoll-Rand pump, driven by 30-horsepower motor. Three-stage plunger booster pump lifts water through 3-inch pipeline, 2 miles to storage tank above mill, capacity 30,000 gallons. The lift to storage tank is 900 feet.

Reported recovery made in treatment of the ore is 80 to 90 percent of the gold and 75 percent of silver.

Analysis of concentrates shipped is as follows:

Gold	52.15 oz.
Silver	844.79 oz.
Lead	23.55%
Copper	1.12%
Insol.	29.40%
Iron	15.80%
Arsenic	0.23%
Antimony	0.67%
Bismuth	0.03%
Calcium oxide	1.80%

Gross value of concentrates $2411.33 per ton. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 61-62.

Coarse Gold Mine. It comprises 5 claims located in the Arrow mining district on the east slope of the Providence Mountains, in sec. 27(?), T. 9 N., R. 14 E., S. B., 22 miles west of Essex, a station on the Santa Fe Railroad; elevation 3200 feet; owner, Coarse Gold Mining Company, John Riddle and W. Stephanson, Fenner, California.

The vein occurs in granite, strikes N. 30° E. and dips 70° E.; width 2 feet. Development consists of shaft 75 feet deep sunk on the vein, with drifts north and south on the 70-foot level for a distance of 100 feet.

Several shipments of ore made are reported to have averaged $26.00 per ton in gold. Equipment consists of 6-horsepower gas engine, hoist and portable compressor with a capacity of 150 cubic feet. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 62-63.

Colosseum mine comprises 2 patented claims, Colosseum No. 1, Colosseum No. 2 and 32 claims held by location, situated on the northwest slope of Clark Mountains, in secs. 10 and 14, T. 17 N., R. 13 E., S. B., 10 miles north of Valley Wells and 23 miles north of Windmill Station, on U. S. Highway 91; elevation 5500 to 6100 feet; owner, Colosseum Mining & Smelting Corporation, C. W. Gowman, president; Earl Thomas, secretary, 7371 West Sunset Boulevard, Hollywood, California. From February 1938 to December 1942, the property was under option to Walter F. Lineberger and Harold Chase, 1012 State Street, Santa Barbara, California.

During this period, 5000 feet of diamond drill work was done to determine the extent of orebodies; also development on lower tunnel level on No. 2 orebody. These parties suspended operations in the latter part of 1942, surrendering their option.

In the immediate vicinity of the Colosseum mine there occurs a great anticlinal fold of thick beds of stratified rocks, consisting of sandstone, limestone, dolomite, and thin-bedded shales. These rest upon gneissoid granite. Into this formation, there has been intruded a large, dome-shaped mass of quartz monzonite. Probably following the granite replacement, an intrusion of rhyolite porphyry occurred, in a general N. 30° E. direction. Subsequent to the intrusion of the rhyolite, intensive fracturing occurred in the rhyolite plug with minor faulting. The major fracture strikes N. 20° W. to N. 20° E. A general mineralization of the rhyolite plug exists along intersecting fractures, metallic minerals being pyrite and chalcopyrite. The pyrite is auriferous. Two types of ore deposits occur. The first, known as No. 1 orebody is a mineralized network of intersecting fractures within the highly altered rhyolite plug. The second type, known as No. 2 orebody is a contact deposit on contact of granite and rhyolite plug. The orebodies strike N. 60° E. and dip 80° SW. Estimated tonnage of ore developed in two orebodies is reported to be 116,000 tons, averaging $8.00 per ton in gold.

Since 1931 [5] the following development work has been done on the property:

At an elevation of 5700 feet and 177 feet in elevation below upper tunnel, a lower tunnel has been driven N. 20° E. 440 feet in granite intersecting shaft at a depth of 200 feet; at 400 feet from the portal, it intersected the contact of granite and rhyolite porphyry. At 435 feet from the portal, a crosscut was run northwest 160 feet to west contact of No. 2 orebody, then drift along contact 160 feet in ore. The orebody developed along contact is 100 feet in length by 12 feet in width. Average value is reported to be $7.85 per ton. Upper tunnel is 800 feet in length; elevation 5877 feet. Upper tunnel level and intermediate tunnel level have developed No. 1 orebody which is 125 feet in length and 60 feet in width. Total amount of development is about 4000 feet.

From well on Mojave tungsten claim, water is pumped through 5000 feet of 2-inch pipe line to water storage tank above mill. Previous to 1938, the mill was operated and produced 1000 tons of concentrates reported to have a value of $20.00 to $40.00 per ton in gold.

All equipment has been removed from the property. Idle.

Bibl.: State Mineralogist's Reports XX, pp. 92-93; XXVII, pp. 291-292.

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[5] Tucker, W. B., and Sampson, R. J., op. cit.

Columbia mine, comprising 4 unpatented claims, is in the Providence Mountains, 6 miles southeast of Dawes, a station on the Union Pacific Railroad, and 15 miles east of Kelso, in sec. 3, T. 11 N., R. 14 E., S. B.; elevation 4800 feet; owner, Mrs. R. P. Greenleaf, 450 South Harvard, Los Angeles.

Here two roughly parallel veins, about 80 feet apart, occur in the quartz monzonite. Strike ranges from N. 65° E. to due east, dip from 40° to 50° S. They range in width from 12 inches to 6 feet. Metallic minerals are pyrite, galena, and sphalerite, and gold and silver minerals. Ore is said to carry $4.00 to $8.00 in gold, 20 ounces silver and 1 to 3 percent zinc.

Development consists of inclined shaft 320 feet, with levels at 100, 200, and 300 feet. On the 300-foot level, a crosscut has been driven south 300 feet to the hanging wall vein and a drift on the vein 300 feet east averages about 4 feet wide.

In 1935-1936, this property was leased to Columbia Mines, Inc., W. T. Potter, president, 2796 Boulder Road, Altadena, California. This company rehabilitated the old 5-stamp mill, added flotation and milled a few tons. This operation apparently was not successful and the property was shut down.

Bibl.: State Mineralogist's Reports XVII, p. 340; XXVII, p. 348.

Cumberland Mine. It comprises 7 claims, located in the Ord Mountain mining district, on the south slope of the Ord Mountains, in secs. 25 and 26, T. 6 N., R. 2 E., S. B., 17 miles northeast of Lucerne and 35 miles east of Victorville; elevation 3500 feet; owners, Harry Fredericks and Hugh Connell, Alhambra, California.

Discovery of ore on these claims was made in 1900 by Samuel Clark, who hauled the ore to Old Woman Springs for treatment in an arrastre.

A quartz vein occurs in granite; strikes north and dips 85° W.; width 18 inches to 3 feet. It is developed by shafts from 50 feet to 135 feet. On the Cumberland claim, the north shaft is 75 feet in depth. About 175 feet south of this shaft is a shaft sunk on the vein to a depth of 135 feet. On the 135-foot level of the south shaft, there is a drift 100 feet north and 50 feet south. The vein quartz developed in these workings is mineralized with hematite, pyrite, marcasite, and chalcopyrite. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 63.

Fremont Peak Mine. It comprises 28 claims situated on the western slope of Fremont Peak, in secs. 33 and 34, T. 31 S., R. 42 E., M. D., 18 miles southeast of Randsburg; elevation 3800 feet; owner, Monarch Rand Mining Company, W. O. Walker, president; Fred P. Rossiter, secretary, 222 S. Thomas Street, Pomona, California.

A series of parallel veins occurs in granite and also on contact of rhyolite porphyry dikes and granite. Veins strike northeast, dip 70° N. Widths vary from 12 inches to 4 feet.

Developments consist of incline shaft sunk on the vein to a depth of 185 feet; on the 50-foot level, drift northeast 275 feet; on the 100-foot level, drift northeast 300 feet; on the 185-foot level, drift 300 feet southwest and drift northeast 1100 feet. At 120 feet west of the shaft a crosscut has been driven northwest 1280 feet, cutting five parallel veins which strike northeast. Ore shoot, developed on the 185-foot level, is 400 feet in length with an average width of 2 feet. The average value

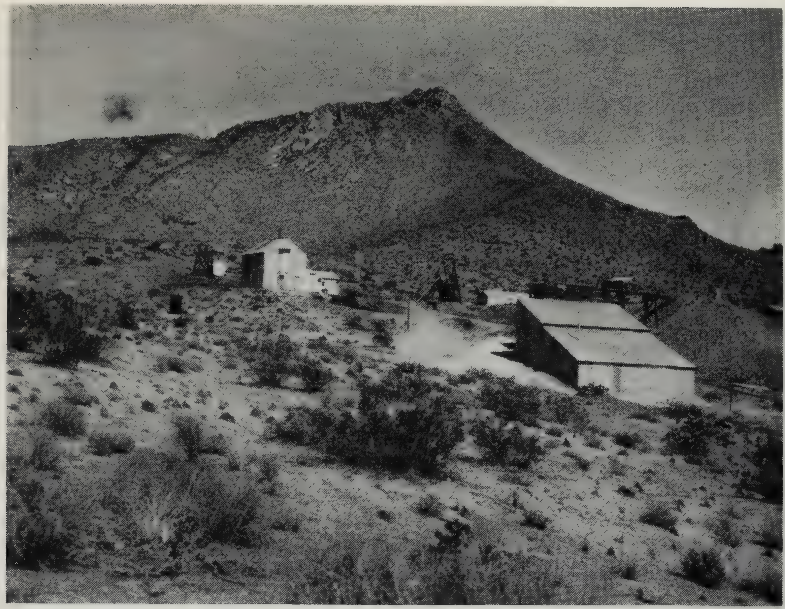

FIG. 2. Shaft and mill, Fremont Peak mine, Monarch Rand Mining Company, Fremont Peak.

is said to be $20.00 per ton in gold. The vein quartz shows gold, mineralized with pyrite and arsenopyrite.

Power plant: 125-horsepower Fairbanks-Morse diesel engine directly connected to 90 K.V.A. generator. The mine equipment consists of 30-horsepower electric hoist (12 inches by 14 inches) (7 inches by 10 inches), Ingersoll-Rand compressor driven by 50-horsepower motor.

Mill equipment: 75-ton coarse ore bin. Ore from the coarse ore bin is fed to a 12-inch by 20-inch Wheeling crusher, driven by a 15-horsepower motor; crushed to $\frac{3}{4}$-inch size; from the crusher to the fine-ore bin, capacity 75 tons, fed by Challenge ore feeders to six 1250-pound Nisson stamps. Each battery of 3-Nisson stamps is driven by a 15-horsepower motor. The ore is crushed to 40-mesh, then pulp to 5-foot by 10-foot amalgamation plates and flows to a Wilfley table, driven by a 5-horsepower motor. Recovery made by amalgamation and concentration was only 60 percent. Therefore operations were suspended. The company plans to install a cyanide plant for treatment of the ore. Water supply is secured from a well 229 feet deep on a small dry lake 2 miles due north of the mine. A Byron-Jackson hydro-pressure pump, pumps the water through 11,000-foot, $2\frac{1}{2}$-inch pipeline to storage tank at the mine. The lift is 1000 feet. The capacity of the pump is 50 gallons per minute. Idle.

Bibl.: State Mineralogist's Report XXX, pp. 324-325.

Gold Bar (*see Vanderbilt Mines*).

Gold Belt Mine. This property comprises 9 claims, situated on the southwest slope of Goat Mountain, in sec. 29, T. 7 N., R. 2 E., S. B., 38 miles northeast of Victorville; elevation 4500 feet; owners, E. L. Mellville Estate, George Henderson and H. V. Bryant, Chula Vista, San Diego County, California.

The country rock is granitic, largely monzonite and diorite. A fissure vein ranging in width from 2 feet to 7 feet, filled largely with quartz and calcite, and in places having a rhyolite casing on the hanging wall side, strikes N. 40° E., dips 45° SE. Mineralization consists of free gold, pyrite and chalcopyrite.

Development consists of vertical shaft 275 feet deep which connects with the mill tunnel. Three levels were driven from this shaft at 50-, 100-, and 240-foot horizons. On the 50-foot level, there is a drift 50 feet southwest and 100 feet northeast, with a 50-foot winze in the northeast drift; on the 100-foot level, drift 50 feet southwest and 40 feet northeast; on the 240-foot level, drift 75 feet southwest and 700 northeast. At 208 feet from shaft, there is a raise 50 feet into the stope which is about 30 feet long. The vein in this stope is 10 inches to 2½ feet wide. At bottom of the shaft, the mill tunnel was driven northeast about 820 feet and a 30-foot raise driven to connect with shaft. At 550 feet from portal, there is a 30-foot raise; at 600 feet from portal, a raise about 180 feet to 100-foot level; at 750 feet from portal, a raise 270 feet to surface. This latter raise was used as an ore pass at each level. At 800 feet from portal raise 30 feet to the 240-foot level.

In 1930 a 40-ton mill was installed on the property by the Gold Belt Mining Company, C. W. Fontaine, president and manager. The plant was operated until the latter part of 1932 when operations were suspended and all equipment removed from the mine. Idle.

Bibl.: State Mineralogist's Reports XXVII, pp. 296-297; XXXVI, pp. 235-236.

Gold Crown Mine (Nightingale and Supply). The property comprises 5 claims in the Nightingale group and 9 patented claims in the Supply group, situated in the Dale mining district, on the northwest slope of the Dale Mountains, in secs. 21, 22, T. 1 S., R. 12 E., S. B., 2 miles east of New Dale and 20 miles southeast of Twenty-nine Palms; elevation 2350 feet; owner, James Hay, c/o Beverly Hills Oil Company, 8517 West Third Street, Los Angeles. Operated by Gold Crown Mining Company, George Novell, president and manager, January 1930 to December 1942.

The Nightingale-Supply vein occurs in andesitic porphyry, strike N., dip 70 to 85° E., and width 4 feet to 12 feet. The Supply shaft was sunk on the Supply vein to a depth of 1250 feet, with levels at 100-foot intervals. There are over 5000 feet of underground workings. Production from the Supply mine is said to have been over $500,000.00. Present work is confined to the Nightingale group. The Nightingale shaft is situated 3600 feet north of the Supply shaft and is on the same vein. The Nightingale shaft has been sunk on an inclination of 85° to a depth of 675 feet. The vein developed is 9 feet to 12 feet in width. The ore shoot developed is 250 feet in length, with an average width of 9 feet. Ore mined is stated to average $12.00 per ton in gold. Levels are at 75-foot intervals. On the 375-foot level, 212 feet south of main shaft, a winze is sunk to the 750-foot level, with levels at 450, 525, 600, 675, and 750 feet. On the 525-foot level drift south 625 feet; on 600-foot level drift south 600 feet; on 675-foot level drift south 600 feet and north 220 feet. A winze is sunk to 825-foot level; on 750-foot level drift south 265 feet. Total underground workings are about 6000 feet. The main working shaft is a 2-compartment shaft with a 60-foot steel headframe.

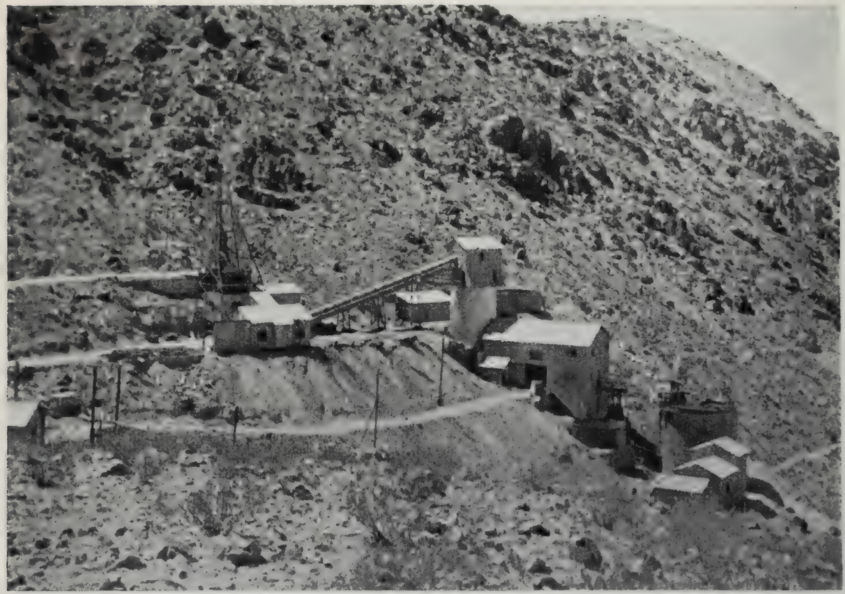

FIG. 3. Gold Crown mine and 50-ton cyanide mill, Dale district, San Bernardino County. *Reprinted from California Journal of Mines and Geology, January 1940.*

Ore is hoisted in 1-ton skip by 25-horsepower electric hoist and dumped direct into steel ore bin with a capacity of 125 tons. From ore bin, ore is fed by belt type of feeder to ½-inch grizzly; then oversize from grizzly to 9-inch by 15-inch Blake type of jaw crusher; ½-inch crusher product to 16-inch incline belt conveyor (120-foot centers) to 300-ton circular steel fine ore bin. From fine-ore bin, ore goes to Hardinge Constant Weight Feeder to 6-foot by 22-foot Hardinge ball mill driven by 75-horsepower motor. The mill is in closed circuit with Dorr duplex classifier. Ore is ground in cyanide solution so 95 percent will pass through 100-mesh screen; overflow from classifier to 5-tray Dorr thickener. From primary thickener, the thickened pulp goes to 2 Devereaux agitators. Gold solution overflows from top tray No. 1 and flows by launder to gold solution tank; the thickened pulp from Dorr thickener to No. 1 agitator, then into No. 2 agitator, where solution is further thickened. From No. 2 agitator, the solution is pumped to No. 2 tray in Dorr thickener. Here the pulp is further thickened and forced downward to No. 3 tray, then No. 4 and No. 5 trays and on out through waste pump to tailings. No. 2 tray overflow passes to work tank, then back to the classifier. The overflow from No. 4, 5, and 3 trays is pumped upward to be passed from No. 2 tray into work tank, then back to classifier. Solution from gold solution tank goes to clarifier where lead nitrate is added, then to deaerator to Merrill-Crowe precipitation process. The recovery is reported to be 95 percent, with loss in tailings from 80 cents to $1.00. (See flow sheet.)

Power plant to operate mill and mine equipment consists of 300-horsepower, 4-cylinder, Fairbanks-Morse diesel engine, direct connected with 170 K. V. A. generator. A 75-horsepower motor drives 300-cubic foot Ingersoll-Rand compressor. Water supply for mine and mill is secured from well 265 feet deep, 10-inch casing. Water is pumped by

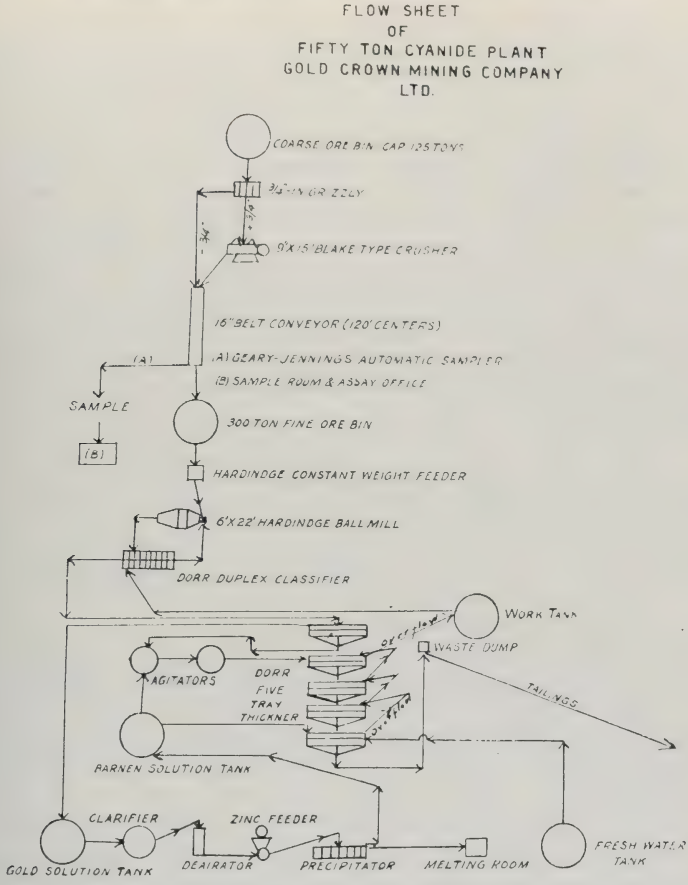
FLOW SHEET
OF
FIFTY TON CYANIDE PLANT
GOLD CROWN MINING COMPANY
LTD.
COARSE ORE BIN CAP 125 TONS
3/4"-IN GRIZZLY
+3/4"
-3/4"
9"X15" BLAKE TYPE CRUSHER
16" BELT CONVEYOR (120' CENTERS)
(A)
(A) GEARY-JENNINGS AUTOMATIC SAMPLER
(B) SAMPLE ROOM & ASSAY OFFICE
SAMPLE
(B)
300 TON FINE ORE BIN
HARDINDGE CONSTANT WEIGHT FEEDER
6'X22' HARDINDGE BALL MILL
DORR DUPLEX CLASSIFIER
WORK TANK
OVERFLOW
WASTE DUMP
AGITATORS
DORR
FIVE
TRAY
THICKNER
TAILINGS
OVERFLOW
BARREN SOLUTION TANK
CLARIFIER
ZINC FEEDER
GOLD SOLUTION TANK
DEAIRATOR
PRECIPITATOR
MELTING ROOM
FRESH WATER TANK

FIG. 4. Flow sheet of 50-ton cyanide plant, Gold Crown Mining Company, Ltd. *Reprinted from California Journal of Mines and Geology, January 1940.*

Byron-Jackson submersible pump driven by 30-horsepower motor, through 3½-inch pipeline 2 miles in length, with a lift of 1400 feet to storage tank at mine, with a capacity of 43,000 gallons. The mill was also operated as a custom plant for ore from mines in the Dale district. Production by Gold Crown Mining Company was reported to be $500,000. Idle and plant dismantled.

Bibl.: State Mineralogist's Reports XV, p. 802; XXVII, pp. 314-315; XXXVI, pp. 63-65.

Gold Divide Mine. It comprises 6 claims situated in the Goldstone mining district, 8 miles east of Goldstone, 25 miles northeast of Barstow, in sec. 22, T. 14 N., R. 2 E., S. B.; elevation 3500 feet; owner, John E. Frey, Barstow, California.

Five parallel quartz veins occur in schist between limestone. The veins strike northwest and dip 80° NE.; width 12 inches to 2 feet. A shaft is sunk on vein on contact of limestone and schist to a depth of 85 feet. Hanging wall is limestone and the footwall schist. About 350 feet south of 85-foot shaft, is shaft 107 feet deep. South on parallel vein is 100-foot shaft on 100-foot level, drift 165 feet on the vein. About 250 feet east of this shaft, a crosscut tunnel is driven east 102 feet in schist.

Mine equipment consists of 12-horsepower hoist. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 66.

Gold Hill Mine. The property comprises 12 claims situated in Bear Valley mining district, in sec. 17, T. 2 N., R. 2 E., S. B., 8 miles east of Pine Knot P. O., Big Bear Lake; elevation 6700 feet to 7280 feet; owners, Albert L. Rose and George W. Tartar, Big Bear Lake, California.

A series of parallel veins in quartzite strikes east and dips 35° to 45° N., width 2 feet to 10 feet. Mineralization occurs along bedding planes of quartzite, near contact of diabase and monzonite. The principal development is on Gold Hill No. 1 and Gold Hill No. 3 claims. On Gold Hill No. 1 claim, a crosscut tunnel is driven N. 35 °E. 1200 feet. At 1150 feet cut vein; strike N. 70° W., with drift west 200 feet. This tunnel is in monzonite for a distance of 175 feet, then in quartzite for the remaining distance. On No. 2 Gold Hill claim, 242 feet in elevation above crosscut tunnel, there is an open cut on mineralized showing along bedding planes of quartzite near contact of diabase. Open cut is 20 feet in length by 10 feet in depth.

On Gold Hill No. 3 claim, vein in quartzite strikes east and dips 35° N.; width 8 feet to 10 feet. Incline shaft sunk on bedding plane on footwall of vein to a depth of 25 feet, developing 3 feet of ore. Thirty feet north of incline shaft, there is a vertical shaft 50 feet deep south of vein, with crosscut to vein. Ore extracted from these workings amounting to about 10 tons, is reported to have averaged $20.00 per ton in gold. There is another shaft south of these workings 20 feet deep sunk on contact of diabase and quartzite.

On Gold Hill No. 7 claim, a crosscut tunnel has been driven southeast 30 feet cutting a cross fracture in quartzite which strikes N. 20° E. and dips 45° W., with a drift south on fissure 30 feet. On Junction claims north of the above-mentioned workings are two shafts sunk on contact of diabase and quartzite to depths of 75 feet. Ore is reported to be low grade. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 66.

Gold Mountain Mines (Lucky Baldwin). The property comprises 16 claims, 8 of which are patented and 8 surveyed for patent, situated in the San Bernardino Mountains, north of Baldwin Lake, in the Bear Valley mining district, in secs. 25, 36, T. 3 N., R. 1 E., sec. 31, T. 3 N., R. 2 E., secs. 6, 7, T. 2 N., R. 2 E., S. B., 6 miles northeast of Big Bear Lake; elevation 7350 feet; owner, James Hulmes Estate, South Pasadena, California. The property is under option to Big Bear Mines Ltd., Inc., Big Bear Lake, Fred C. Cline, president; C. Woods, secretary and manager.

The vein system consists of irregular bodies of massive quartz in quartzite on contact with schist; with schist footwall and quartzite hanging wall. The strike of the orebody is N. 60° W., dip 30° to 60° S. Average width of the vein is 40 feet. The principal mineralization occurs along cross fractures in the quartzite that strike northeast.

Development consists of glory hole 600 feet in length by 40 feet wide and 50 feet deep. Main adit tunnel is 700 feet in length, driven N. 60° W. 85 feet vertically below outcrop. The ore mined from the glory hole is said to have an average of $6.00 per ton.

The present operator has installed a mill with a capacity of 40 tons. Ore from glory-hole level is mined, loaded in cars to coarse-ore bin with a capacity of 200 tons; ore from bin to 9-inch by 15-inch jaw crusher, then to 9-inch by 15-inch secondary jaw crusher to fine-ore bin, capacity of 200 tons; from fine-ore bin by belt feeder to No. 65 Marcy ball mill in closed circuit with Dorr classifier, ground to minus 100 mesh, to 12 cells of Pan American flotation machines. A high-grade gold concentrate is produced and shipped to Selby Smelting & Lead Company.

Water is secured from Baldwin Lake and pumped by Gould triplex pump through 3-inch pipe line 6000 feet in length to storage tank at mine; Gardner-Denver air compressor. Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 346-347; XII, p. 232; XIII, p. 322; XXVII, p. 298; XXXVI, pp. 66-67.

Gold Point Mine (Murray Mining Company). It comprises 12 claims known as the Golden Chariot group, on the east slope of the San Bernardino Mountains in the Black Hawk mining district, in sec. 1, T. 3 N., R. 1 E., S. B., 35 miles southeast of Victorville, California; owner, Abba Gold Mining Corporation, Max E. Socha, president; James C. Brazell, secretary; Fred H. Nett, treasurer, 738 Eighth Street, San Bernardino, California.

The vein occurs on the contact of brecciated dolomite and granite. The vein strikes northeast and dips 35° SW.; width 4 to 6 feet. Development consists of two tunnels, upper tunnel driven 200 feet on contact and lower tunnel 600 feet in length. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 305-306.

Gold Rose Mine. It comprises 6 claims situated in the Dale mining district, adjoining the Los Angeles group of mines on the southwest and on the south slope of the Dale Mountains, 45 miles northeast of Mecca, in sec. 32, T. 1 S., R. 13 E., S. B.; elevation 1700 feet; owners, C. A. Foletta, C. L. Allison, and Dale Holmes, San Bernardino, California.

Four parallel veins occur in granite. The veins strike northwest and dip 70° to 80° NE. The veins range in width from 2 feet to 6 feet. Developments consist of 5 shafts sunk on different veins to depths of 50 feet to 250 feet. No. 2 shaft on the west side of Brooklyn Wash is 235 feet deep, sunk on an inclination of 70°. Gold Rose No. 4 shaft is sunk on vein east of wash. The shaft has been sunk to a depth of 200 feet on an inclination of 80°. On 100-foot level there is a drift south on vein 200 feet; on 200-foot level, drift south 240 feet. On the same vein about 500 feet south of shaft, there is a shaft 100 feet deep and a tunnel 50 feet in length. Vein is 6 feet wide. Vein quartz is mineralized with gold associated with pyrite, chalcopyrite and galena.

Mine equipment consists of 12-horsepower Novo gas-driven hoist; Rix compressor driven by LeRoi gas engine; no. 6 blower. Ore from mine is dumped into bin with a capacity of 25 tons; 7- by 10-inch Blake crusher; Wheeler ball mill, driven by 40-horsepower Holt gas engine. Ore is ground in ball mill to pass 40-mesh screen; pulp from ball mill to amalgamating jig, then over amalgamation plates; to steel cone tank; overflow from cone to two 5-foot by 8-foot steel settling tanks. Water from final settling tank is pumped back to head of mill. Idle.

Bibl.: State Mineralogist's Reports XXVII, pp. 298-299; XXXVI, p. 67.

Hafford mine comprises Hafford No. 1 patented claim and 6 claims held by location, situated on the east slope of Slate Mountains, in secs. 14, 15, 22, 23, T. 25 S., R. 45 E., M. D., 14 miles east of Trona. Elevation is 2800 to 4200 feet; owner, James McDonald Manning, Tucson, Arizona; under lease to R. M. Sanderson, South Pasadena, California.

The vein occurs on contact of schist and granite. The foot-wall is granite, with schist hanging wall. The vein strikes N. 30° W., dip 85° E. Width ranges from 2½ to 5 feet. Development consists of shaft sunk on the vein to a depth of 100 feet, with levels at 50 and 100 feet. On 50-foot level, there is a drift north 40 feet and south 40 feet; on 100-foot level, drift north 65 feet. It is reported that 10,000 tons of ore are developed, averaging $25.00 per ton in gold. Idle.

Hoganson Mine. It comprises 6 claims situated in the Silver Mountain mining district, in sec. 14, T. 6 N., R. 4 W., S. B., 4 miles east of Oro Grande; elevation 3500 feet; owner Hoganson Mining Company, N. A. Hoganson, president; E. A. Meek, secretary; Henry S. Johnson, manager, Culver City, California.

A quartz vein 4 feet in width occurs in quartz monzonite; strike northwest, dip 70° SW. Samples taken from vein are reported to carry from $10.00 to $16.00 per ton in gold. Development consists of a shaft sunk on the vein to a depth of 125 feet, with drifts on the 50-foot and 100-foot levels. Idle.

Ivanhoe Mine. It comprises 13 claims situated in Dale mining district, on the east slope of the Dale Mountains, 2½ miles east of New Dale and 22 miles east of Twenty-nine Palms, in sec. 7, T. 1 S., R. 13 E., S. B.; elevation 3000 feet; owner, Denny B. Pardo, San Bernardino, California.

Three parallel veins known as Top Nest, Hidden Treasure and Ivanhoe, occur in andesitic porphyry. The veins strike N. 20° W. and dip 80° E. Widths of veins range from 2 feet to 6 feet. The vein quartz is stained with copper oxides and shows considerable hematite and some free gold associated with pyrite and chalcopyrite. The principal development is confined to the Ivanhoe vein. On this vein a shaft has been sunk to a depth of 215 feet, with levels at 75, 125 and 200 feet, with about 1000 feet of drifts.

Equipment consists of 15-horsepower gas-engine hoist and compressor. Mill is at New Dale and consists of 25-ton cyanide plant. Idle.

Bibl.: State Mineralogist's Reports XXVII, p. 302; XXXVI, p. 68.

Jupiter Mine. It comprises 5 claims situated in the Dale mining district and adjoins the Carlyle mine on the west and south, in sec. 11, T. 1 S., R. 12 E., S. B., 7 miles northeast of New Dale and 23 miles southeast of Twenty-nine Palms; elevation 2500 feet; owner, Sels Bush, Twenty-nine Palms, California. During 1937 the property was under option to Frank A. Berger and Mathew Bilber, Beverly Hills, California. During this period these parties mined 1000 tons of ore which was milled in the Carlyle mill, and said to have averaged $25.00 per ton in gold. Some ore was also shipped to the Gold Crown mill for treatment.

Two parallel veins occur in andesitic porphyry. One, known as Bodsworth, is 30 feet east of Jupiter vein. The principal development work is confined to the Jupiter vein. The veins strike N. 14° E. and dip 80° W.; width 2 feet to 8 feet. Development consists of tunnel driven south 200 feet, and several hundred feet of crosscuts and raises. Considerable development work was done on the south end of this group of claims, consisting of a shaft 200 feet deep. A road was constructed to the south end of the property from the Supply mine. Idle.

Bibl.: State Mineralogist's Reports XXXIV, p. 15; XXXVI, p. 68.

Long Shot Mine. The property comprises 7 claims situated in the middle portion of the Old Woman Mountains, in secs. 30 and 32, T. 6 N., R. 17 E., S. B., 16 miles southeast of Danby, a station on the Santa Fe Railroad; elevation 3600 to 4900 feet; owners, L. J. Rouchleau and Mrs. M. M. Richardson, Los Angeles.

The formation is granite, with inclusions of mica and hornblende schists. The Long Shot vein occurs in granite, strikes N. 40° W. and dips 70 to 75° SW.; width 12 inches to 4 feet. The vein occurs along a well-defined fracture in the granite and can be followed along its outcrop for a distance of 6000 feet. There is also a series of parallel N. 55° E. veins that intersect the main Long Shot vein. Some of these veins have been productive.

The principal development work, however, has been confined to the Long Shot vein. At an elevation of 4000 feet, a shaft has been sunk on the vein to a depth of 70 feet. A crosscut tunnel has been driven west 40 feet to vein; then a drift driven northwest 179 feet intersecting shaft on the 70-foot level. On the 50-foot level, there is a stope 60 feet in length stoped up to 10 feet above 50-foot level. The vein stoped had a width of 12 inches to 2 feet. The ore extracted is reported to have an average value of $35.00 per ton. The quartz is mineralized with pyrite and chalcopyrite, the gold being in the sulphides. About 160 feet in elevation below these workings, a crosscut tunnel has been driven west 300 feet intersecting the vein. Ore shipped from the property by former owners to International Smelting Company and the United States Smelting & Refining Company, Salt Lake City, Utah, carried from .96 ounces to 1.57 ounces in gold per ton. The upper camp has an elevation of 3740 feet. At this point there is a 220-cubic foot Chicago Pneumatic compressor from which a 2-inch pipeline extends 900 feet to lower crosscut tunnel. At upper crosscut tunnel, there is 80-cubic foot compressor. Water from spring near upper camp has a flow of 1800 gallons in 8 hours. From upper tunnel there is a jig-back tramline to upper camp 1000 feet in length. There are also a number of shallow shafts and open cuts on the main vein to depths of 20 feet to 50 feet. On the intersecting veins are a number of shafts 50 feet in depth and a tunnel 150 feet in length, with jig-back tramlines to lower camp. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 69.

Los Padre Mine. It comprises 8 claims situated in Dry Lake mining district, 36 miles east of Lucerne P. O. and 55 miles southeast of Victorville, in sec. 18, T. 4 N., R. 6 E., S. B.; elevation 3500 feet; owners, Los Padre Mining Company, M. C. Clemens, president; C. B. Caldwell, secretary, 540 Title Insurance Building, Los Angeles.

The vein strikes east and dips 80° S.; width 2 feet to 3 feet. It occurs in gneissoid granite. Development consists of crosscut tunnel driven north 700 feet to Padre vein, with drift east on the vein 80 feet and 300 feet west. An incline shaft was sunk on the vein from the surface to a depth of 150 feet and intersected the west drift 50 feet north of lower crosscut tunnel. There is an upper tunnel driven on the vein which intersects the shaft 50 feet below collar of shaft and a drift on the vein 200 feet northwest. Some high-grade gold ore was recovered from the upper workings, the gold in the quartz being in wire form. The west drift in lower tunnel level developed an ore shoot 30 feet in length with an average width of 18 inches. The company sank a well about half a mile west of the property, developing sufficient water for camp and milling purposes. A 20-ton amalgamation and concentration plant has been installed on the property. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 70.

Merrick Mine (Gold Crown Group). It comprises 13 claims situated in Goldstone mining district adjoining the Belmont group of mines on the east, in sec. 35, T. 14 N., R. 1 E., S. B., 34 miles northeast of Barstow; elevation 3200 feet; owner, Mitchell Merrick Estate, Goldstone, California.

A series of stringers and quartz veins occurs in a belt of schist about 500 feet in width; strike northwest, dip 30° to 40° NE. On the east edge of this belt of schist is a diorite intrusion. Development consists of a crosscut tunnel driven southwest 124 feet, with 30 feet of backs. This tunnel intersected a number of stringers and quartz veins; widths 2 inches to 12 inches. South of this tunnel on ridge above the tunnel, a number of open cuts and shallow shafts were sunk on different veins of quartz. Thirty-three tons of ore were mined and shipped to Burton Bros., Inc., Rosamond, California, valued at $1370.00. About 500 feet northwest of these workings, a shaft was sunk by Beale and Baily to a depth of 100 feet on an inclination of 40°. The vein strikes northeast and dips 40° NW.; width 12 inches. Ore shipped to Burton Bros., Inc., amounted to $2000.00. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 804-807; XXXVI, pp. 70-71.

Morning Star mine, comprising 12 claims, is in secs. 27, 28, 33, and 34, T. 15 N., R. 14 E., S. B., on the east slope of the Ivanpah Mountains, 8 miles north of Cima, a station on the Union Pacific Railroad; elevation 4400 feet; owner J. B. Mighton, Cima, California; under lease to Earl P. Halliburton, 1709 West Eighth Street, Los Angeles.

The country rock is monzonite which has been fractured and mineralized with auriferous pyrite across widths up to 175 feet. Both east-trending and north-trending fractures occur in this rock. These fractures are filled with quartz and it is here, particularly in the north-trending fractures, that the better grade of ore is found.

Development consists of tunnel driven north about 600 feet, 350 feet below the outcrop. At 185 feet north of the portal, there is a crosscut west 175 feet; also a winze sunk on 32° inclination, to the west 240 feet, with drifts at 200-foot level, south 100 feet and north 640 feet, with a crosscut west at 400 feet and a crosscut west 100 feet at 40 feet south of face. At 400 feet north of this winze, another winze has been sunk on the same inclination 420 feet. This work was done on a north-trending fracture. Also several diamond drill holes were fanned out into the rock from the crosscuts. The lessees estimate that this work has developed 500,000 tons of ore which will average $7.00 per ton in gold.

Operations ceased in accordance with the War Production Board's Order L-208, closing gold mines.

Bibl.: State Mineralogist's Reports XXVII, pp. 304-305; XXXVI, p. 71.

Old Pete Mine (Yim-Wheelock). It comprises 3 claims, totaling 60 acres in the Buckeye mining district, in sec. 33, T. 7 N., R. 8 E., S. B., 4 miles south of Ludlow; elevation 2200 feet; owners, Lee Yim, William Wheelock Estate, of Ludlow, California, and Ralph Swing, San Bernardino, California.

The ore occurs in a brecciated dacite porphyry on contact with monzonite. The mineralized zone is 30 feet to 50 feet in width and about 600 feet in length. Strike is north, dip 30° E. The average grade of ore shipped from the property was 0.81 ounces per ton in gold, with some shipments carrying 1.8 ounce per ton. Total production to date is $25,000.00 to $30,000.00.

Development consists of tunnel driven south 60 feet about 10 feet in elevation below open cut. Open cut is 50 feet in length by 30 feet in width and 40 feet below outcrop. Tunnel driven west about 100 feet from the floor of glory hole; incline winze at north edge of glory hole about 60 feet deep; also short tunnels and open cuts south of glory hole (open cut) at higher elevations. Idle.

Bibl.: State Mineralogist's Reports XXX, p. 326; XXXVI, p. 240.

Oro Fino Mine. It comprises 4 claims situated in the Solo mining district, in the Old Dad Mountains, in sec. 10, T. 12 N., R. 10 E., S. B., 12 miles southeast of Baker; elevation 2200 feet. Owners are Jerry Korfist and Wilbur Lawson, Baker, California; under lease and option to J. P. Howard, 2628 Main Avenue, Long Beach, California.

The country rock is limestone and quartzite, with intrusions of diorite dikes. The vein occurs in limestone and quartzite. It strikes N. 60° E. and dips from 30° to 60° northwest. Width of vein varies from 3 to 12 feet. The vein has been faulted by a series of step faults, the displacement being but a few feet. The vein filling is quartz, mineralized with free gold and auriferous pyrite. The values are about 75 percent free. The vein has been prospected along its outcrop for a distance of 1500 feet.

Development: A tunnel has been driven on a cross fracture N. 25° E., 175 feet to main vein, then 150 feet N. 60° E. This work exposed an ore shoot on the main vein in excess of 150 feet, with an average width of 7 feet. The ore mined is reported to average $9.00 per ton in gold. At 260 feet from the portal of tunnel, a raise has been put up 87 feet to the surface. For a distance of 1300 feet northeast from this tunnel, the vein has been exposed by numerous cuts and shallow shafts. Bunches of ore have been taken from these openings, with widths up to 6 feet. Thirteen hundred feet northeast of main tunnel is a shaft 65 feet deep and on the 30-foot level, there is a stope about 60 feet long, 6 feet wide and 30 feet high, on a flat dip. It is reported that 4000 tons, averaging $50.00 per ton has been shipped from these workings. The deposit appears to be a succession of short lenses. Total production of the property has been about $50,000. Idle.

Prosperity Group of Mines (Golden Star). It comprises 10 claims situated on the northeast slope of the Turtle Mountains, 26 miles southwest of Needles, in sec. 23, T. 3 N., R. 21 E., S. B.; elevation 2000 feet; owner, Charles H. Brown, Needles, California.

Three parallel veins occur in granite, strike east, dip 30° S.; width 18 inches to 2 feet. The veins are about 30 feet apart. Vein quartz shows free gold associated with pyrite and chalcopyrite. Development consists of incline shaft sunk on the vein to a depth of 100 feet, with 100 feet of drifting on the 50-foot level. About 3000 feet west of this shaft, a shaft has been sunk on the vein to a depth of 150 feet. All present work is confined to East shaft.

Mine equipment consists of 50-horsepower, 2-cylinder Fairbanks-Morse diesel engine, direct-connected with Westinghouse generator; portable compressor. Mill has a capacity of 25 tons; 8-inch by 15-inch Wheeling crusher to fine-ore bin, capacity 50 tons; then by belt feeder to 3-foot by 4-foot Gibson rod mill, equipped with elliptic roll. Ore is ground to minus 80 mesh. Pulp from mill goes to Gibson amalgamator from which it flows to Gibson concentrator. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 72.

Ramsey Mine (Wheeler). The property comprises 12 claims situated on the ridge south of Grapevine Canyon, in secs. 2 and 3, T. 3 N., R. 2 W., S. B., on the east slope of the San Bernardino Mountains, 15 miles southeast of Victorville and 5 miles south of Fifteenmile Point; elevation 4500 to 6000 feet; owner, Ramsey Mining Company, Milton G. Ramsey, president and manager. This company acquired the property the latter part of 1936 and the property has been under operation until 1940.

Two parallel veins about 500 feet apart, occur in gneissoid granite. These veins occur along diorite dikes, the diorite being on the footwall of the quartz veins in granite. The West vein strikes N. 20° W. and dips 25° W. The East vein strikes north and dips 50° to 70° W. Widths range from 6 inches to 4 feet. As a rule when the veins pinch to a width of 6 inches to 12 inches, the values increase. The vein quartz is mineralized with free gold, associated with pyrite and chalcopyrite. The veins can be traced along the surface outcrops for a distance of 6000 feet.

Development: The principal development at present is confined to the West vein. About $\frac{3}{4}$-mile south of the mill at an elevation of 6000 feet, a shaft has been sunk on an inclination of 80°, intersecting the vein at a depth of 40 feet. Then the remaining distance of 60 feet is on the vein which has a dip of 25°. Drifts have been driven north and south on the 40-foot level and also on the 65-foot level. North of the shaft, a tunnel has been driven south on vein a distance of 40 feet. This tunnel will intersect shaft on 40-foot level. The vein has been underhand stoped for a distance of 20 feet to a depth of 10 feet. The vein has an average width of 3 feet and is reported to carry from $20.00 to $50.00 per ton in gold. About 500 feet north of the shaft, a tunnel has been driven north 150 feet, with 50 feet of backs. Ore is stoped to the surface for a length of 50 feet. About 500 feet north of these workings, a tunnel has been driven south on the vein a distance of 200 feet. Ore shoot 100 feet in length, 2 feet wide, is stoped to the surface for a distance of 60 feet. Two winzes are being sunk from tunnel level. One is 100 feet in depth, the other 150 feet deep. About 200 feet north of No. 1 shaft, a crosscut tunnel has been driven west 200 feet to the vein, with drift south on the vein 150 feet.

Ore mined from the above-mentioned workings is hauled by tractor in trailer having a capacity of 2 tons to the mill. In canyon about half a mile northeast of mill, a tunnel has been driven south 600 feet on East vein, about 200 feet below the outcrop. Average width of vein is 2 feet. There is also a series of east-trending veins but only developed so far by shallow open cuts.

Mine equipment consists of 2 Ingersoll-Rand compressors, one with a capacity of 100 cubic feet, the other with a capacity of 70 cubic feet; one Ingersoll-Rand tugger hoist and 15-horsepower single drum, Novo gas engine hoist.

Mill: 25-ton counter-current cyanide plant. Mill was driven by 90-horsepower, 3-cylinder, Fairbanks-Morse, diesel engine, direct connected, with 45 K. V. A. generator. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 72-73.

Reward Mine. It comprises 4 patented claims situated in the Goldstone mining district, in secs. 2, 3, 10, and 11, T. 13 N., R. 1 E., S. B., on the north slope of the Paradise Mountains, 26 miles north of Barstow and 12 miles north of Paradise Springs; elevation 4600 feet; owner, Reward Mining Company, Julian Itter, president and manager, Beverly Hills, California; J. N. Thiele, secretary, Santa Paula, California.

The Reward vein occurs in schist, strike N. 30° W., dip 75° W. Width ranges from 2 feet to 6 feet. A lime-silicate dike forms the footwall of the vein, schist the hanging wall. A tunnel has been driven N. 30° W. 600 feet. At 50 feet north of portal of the tunnel developed an ore shoot 150 feet in length, with an average width of 4 feet. Two raises have been put up to the surface, a distance of 60 feet. Ore is stoped out. These raises are 125 feet apart. At 350 feet from portal of tunnel cut lime-silicate dike. The vein quartz shows free gold associated with pyrite, chalcopyrite, and marcasite. Ore milled is stated to average $30.00 per ton in gold. At 570 feet from the portal of tunnel on contact of lime-silicate dike developed some small lenses of copper ore. The mineral was chalcopyrite associated with pyrite. Samples taken stated to carry from 4 to 15 percent copper, $1.40 per ton in gold. At this point, a winze was sunk on an inclination of 20° to a depth of 112 feet.

About 7 miles west of the mine the company drilled a well 375 feet deep, developing water, and installed a 20-ton amalgamation mill. After a short operation, the mill was sold to L. V. Storrs, of Hollywood, California. Idle.

Bibl.: State Mineralogist's Reports XXXIV, p. 15; XXXVI, pp. 73-74.

Rio Hondo Mine. It comprises 6 claims situated in the Goldstone district, 2 miles northeast of Reward mine and 28 miles north of Barstow, in sec. 33, T. 14 N., R. 2 E., S. B.; elevation 4350 feet; owner, Vernon Jay, Barstow, California.

The formation is schist, limestone, and granite. A quartz vein occurs in limestone, strike N. 50° W., dip 80° N.; width 3 feet to 6 feet. Ore developed is reported to carry from $7.00 to $15.00 per ton in gold. The quartz carries free gold associated with pyrite. Development consists of open cut 100 feet in length, and 4 to 6 feet in depth; shaft 72 feet deep and about 50 feet southeast, a shaft 90 feet deep; tunnel 20 feet long.

Mine equipment consists of a Chicago Pneumatic Hot Head compressor. Mill: 10-inch by 12-inch Universal crusher; 4-foot by 4-foot ball mill; Dorr classifier and amalgamation plates. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 74.

Roulette Mine. It comprises 23 claims situated in the Monumental mining district in the Whipple Mountains, in sec. 8 (?), T. 3 N., R. 26 E., S. B., 7 miles northwest of the Parker Dam and 22 miles northeast of Earp, a station on the Santa Fe Railroad; elevation 1000 feet; owner, John P. Fleming, Vista, California.

A series of roughly parallel veins in quartz porphyry and diorite strikes north and dips 26° to 30° W. Width of veins ranges from 2 to 6 feet. On the Roulette vein an incline shaft has been sunk on the vein to a depth of 70 feet. The vein developed has an average width of 5 feet.

Ore which was mined and milled from shaft is reported to have averaged $8.00 per ton. On a parallel vein there is a tunnel driven south 90 feet in length. The other veins are developed by open cuts and shallow shafts. Ore was milled in a 40-ton flotation plant.

Equipment consists of portable compressor and air drills. Idle.

Santa Fe Mines (Arlington and Black Hawk Mines). The property comprises a group of 175 claims known as the Black Hawk group of mines, situated in secs. 5, 8, 9, 16, and 17, T. 3 N., R. 2 E., S. B., on the east slope of the San Bernardino Mountains, 35 miles southeast of Victorville; elevation 4200 to 6700 feet; owner, James Hay, 8517 West Third Street, Los Angeles. The property was operated by the Santa Fe Gold Mines, Inc., Hewitt S. West, president; W. Lunsford Long, chairman of the board; Harlan H. Bradt, managing engineer; J. E. Moore, Jr., general superintendent; Algernon Del Mar, consulting metallurgist; offices, 55 Liberty Street, New York, N. Y. Local offices are in Pacific Southwest Building, Pasadena, California. The property was operated from January 1939 to July 1940 by Santa Fe Gold Mines, Inc.; from July 1940 subleased to Mines, Inc., H. S. West, president; J. E. Moore, Jr., manager, and operated until December 1942.

The formations that occur in the vicinity of Black Hawk Canyon are gneissoid granite, overlain by white, gray, or reddish metamorphic limestone and a series of interbedded sandstone. Along Black Hawk Canyon, the limestone is in the form of a breccia slightly silicified, with red iron (hematite) streaks running through the brecciated mass that gives it a pinkish or reddish color. The fragments are slightly cemented together, stained red, being principally calcite, with some dolomite and fine, irregular grains of quartz. The footwall of the ore zone is granite, the hanging wall massive limestone. The Black Hawk lode, which follows along Black Hawk Canyon, strikes N. 20° E. and dips 5° to 20° SW. The Arlington-Santa Fe lode strikes N. 80° E. and dips 5° to 20° S. The crushed zone is at least 100 feet thick, with a gneissoid granite footwall and limestone hanging wall. The gold occurs in the soft material that forms the filling between the crushed fragments, and not in the pieces of hard rock. The richest ore is found in hematite streaks that occur at intervals throughout the crushed zone, and the whole is free-milling. Ore was mined from the Arlington-Santa Fe lode at an elevation of 6200 feet along the lode. *A workings:* Consist of an open cut 200 feet in length along the strike of the lode, with a height of 50 feet above the floor of the cut. A $\frac{1}{2}$-yard P & H shovel loaded ore into trucks for delivery to screening plant. *B workings:* Consist of crosscut tunnel driven south 400 feet; connects with glory hole. Ore was hauled by train of 10 cars with a capacity of 2 tons each, by storage battery locomotive to receiving bins at screening plant. Farther west is crosscut tunnel No. 2 driven south 400 feet connecting with a glory hole. *C workings:* Ore from this crosscut tunnel was delivered on train to receiving bin. About 500 feet east of Calle de Oro mine workings, is an open cut about 100 feet in length and 50 feet in height. Ore from these workings was delivered by caterpillar tractor to ore bin from which it went through 16-inch pipeline to main receiving bin. Mining from open cut east of Calle de Oro mine workings, exposed a high grade vein of ore on footwall. Mines, Inc. sank an incline shaft on the vein to a depth of 175 feet and mined ore is reported to carry from $30.00 to

$200.00 per ton. It is reported that this high-grade ore shoot, which was about 200 feet in length, and ranged from 2 feet to 4 feet in width, produced $90,000. All ore over $30.00 per ton was shipped to Selby Smelting Company; while ore carrying $30.00 per ton was treated in a 30-ton cyanide plant installed on the property and operated by Mines, Inc.

The 600-ton cyanide leaching plant[6] was shut down in July 1940, as ore treated was found too low grade to be profitable. All equipment has been removed from the property.

Water for camp and milling operations was secured from Arrastra Creek through 5-inch pipeline, 4½ miles in length; flows by gravity to 11-foot by 34-foot storage tank, with a capacity of 35,000 gallons. Electric power was secured from the Southern Sierras Power Company over a power line 6 miles long from sub-station in Arctic Canyon. Total production reported as $300,000. Idle.

Bibl.: State Mineralogist's Reports IX, p. 226; X, p. 524; XI, p. 364; XII, p. 230; XIII, p. 330; XV, pp. 797-798; XXVII, pp. 282-286; XXXVI, pp. 74-78.

Sulphide Queen mine, comprising 6 claims, is in secs. 12 and 13, T. 16 N., R. 13 E., on the southeast slope of Clark Mountain, half a mile northeast of Mountain Pass, a station on Las Vegas highway, about 40 miles northeast of Baker; elevation about 5000 feet; owner, Fred B. Piehl, Baker, California.

The formation is gneissoid granite in which there are aplite dikes which strike N. 30° W. The principal development is on a vein which occurs at the contact of an aplite dike and the granite. The dike is the hanging wall of the quartz vein, the granite the footwall. The strike is N. 32° W., dip about 70° SW. Width varies from practically nothing to approximately 17 feet.

Development consists of a shaft sunk on 60° to 114 feet, then 55° to 365 feet, with levels at 65, 114, 213, and 315 feet. On the 65-foot level, adit driven northeast 135 feet connects with shaft. On 114-foot level, drift southeast 100 feet, northwest 200 feet; and at 30 feet northwest of shaft, raise 65 feet; on 215-foot level, drift southeast 100 feet, northwest 300 feet, with a 70-foot winze 190 feet northwest of shaft and a raise 75 feet, 100 feet northwest of shaft; on 313-foot level drift southeast 50 feet, northwest 210 feet. The ore shoot developed is about 100 feet long, up to 12 or 15 feet in width and is said to carry $9.00 per ton in gold, the valuable minerals being auriferous pyrite, free gold, and some galena.

Mine equipment consists of gasoline hoist, 309-cubic foot Chicago Pneumatic compressor, blacksmith shop, etc.

The following mill (which has since been partially dismantled) was erected on the property in 1940: Bin to 10-inch by 16-inch jaw crusher, set at 1½-inch to 20-inch conveyor, discharging through a Vezin sampler to bin, to ⅜-inch screen to 16-inch by 20-inch rolls to bin by screw conveyor to 6-foot by 80-foot rotary roaster, oil fired 480° to 500° to drive off arsenic in the ore. Roasted ore is elevated to steel bin, reciprocating feeder to screw conveyor to sampler to 5-foot by 8-foot ball mill in closed circuit with Dorr duplex classifier to 30-foot Dorr thickener to three 18-foot by 20-foot agitators, in series, to five 30-foot by 8-foot thickeners, counter current decantation to pregnant solution tank to Merrill-Crowe precipitation. Capacity is 150 tons per day.

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[6] For description of this plant see: Tucker, W. B., and Sampson, R. J., Current Mining Activity in southern California: California Div. Mines Rept. 36, pp. 74-78, 1940.

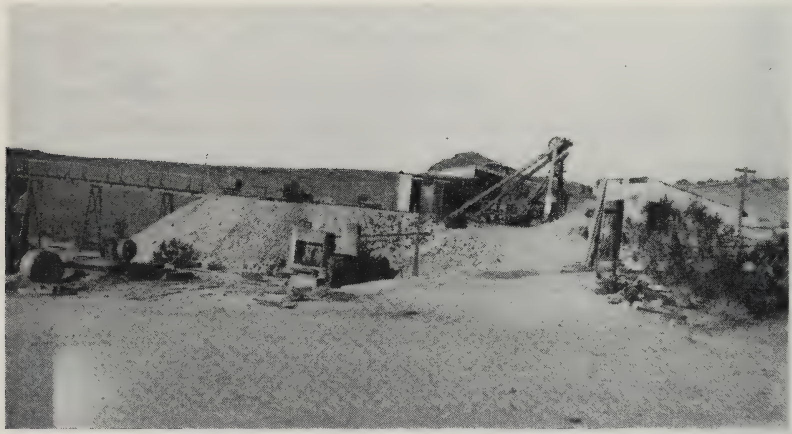

FIG. 5. South shaft, Telegraph mine, Solo mining district, Yucca Grove.

Water was pumped 2 miles through a 3-inch line from a 50-foot shaft and 200-foot crosscut south of the mine, the lift being 112 feet. Idle and plant partially dismantled.

Bibl.: State Mineralogist's Report XXXVI, pp. 78-79.

Telegraph Mines. The property comprises 5 claims situated in secs. 16, 17, and 20, T. 15 N., R. 11 E., S. B., in the Solo mining district, 17 miles east of Baker, a station on the Tonopah & Tidewater Railroad; elevation 3500 to 4000 feet; owner, Telegraph Mines, Inc., J. T. Hutton, president; Andrew Bauer, secretary, Long Beach, California; under lease to J. W. Belcoe, Ouray, Colorado.

The property was located on November 19, 1930, by Ralph and A. A. Brown, of Salida, Utah. Discovery of a high-grade streak of ore was made on Telegraph Extension claim which caused a revival of mining activity in this old district. O. Perry Riker of Long Beach, California, operated the property under lease from December 1932 (?), to January 1935. During this period he shipped 220 tons of ore to the mill at Yucca Grove, operated by the Consolidated Metal Mines, Ltd., of Salt Lake City, Utah. The ore treated was reported to average $16.00 per ton in gold; also shipped to smelter 909 tons; value $18,963. Solo Engineering Company, of Long Beach, California, also had a lease and option on the property. Total production of the property was $35,200.00.

Calcite-quartz vein occurs in granite, with a strike of N. 30° E., dip of 30 to 50° NW. Width of vein ranges from 4 feet to 8 feet. The vein occurs along aplite dike that has the same general strike and dip. This dike forms the footwall of the vein, granite the hanging wall. Since 1931 [7] the following amount of development has been done on the property: On South Telegraph claim, at an elevation of 3750 feet, a shaft has been sunk on an inclination of 52° to a depth of 125 feet; on the 75-foot level, drift north 250 feet on vein, with drift south 115 feet. Ore shoot developed on this level is 250 feet in length; average width 6 feet. It is reported to have an average value of $9.00 per ton in gold. On Telegraph Extension claim, a shaft has been sunk on the vein to a depth of 100 feet. The dip of the vein is 35° W.; width 6 feet to 8 feet. Two hundred tons of ore mined and milled from Telegraph Extension shaft is reported to have averaged $16.00 per ton in gold. Present lessee sank a shaft about 100 feet northeast of those workings expecting to hit the vein at 117 feet, and intended to drift southwest 200 feet. Shaft was 75 feet deep September 15, 1941.

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[7] Tucker, W. B., and Sampson, R. J., San Bernardino County; California Div. Mines Rept. 27, p. 332, 1931.

Mine equipment consists of C. P. compressor, capacity 110 cubic feet; also Gardner-Denver Compressor, with a capacity of 118 cubic feet; 12-horsepower Western gas engine hoist.

Mill equipment consists of 25-ton ore bin; 8-inch by 10-inch Blake crusher; 3-foot by 6-foot Hartman ball mill in closed circuit, with Simplex Dorr classifier, ground to minus 60-mesh, then to 8-foot K & K flotation machine; tails to waste. Concentrates produced are reported to carry $300.00 to $400.00 per ton in gold. Idle.

Bibl.: State Mineralogist's Reports XXVII, p. 332; XXXVI, pp. 79-80.

Top Nest Mine. It comprises 6 claims situated in Dale mining district, on the east slope of the Dale Mountains, in sec. 7, T. 1 S., R. 13 E., S. B., 3 miles northeast of New Dale and 22 miles east of Twenty-nine Palms; elevation 3000 feet; owner, Hayward Lumber Company, Palm Springs, California; was under lease to E. G. Johnson, Palm Springs, California. The property adjoins the Ivanhoe group of claims on the northwest.

The Top Nest vein occurs in andesitic porphyry; strike N. 20° W., dip 80° E. Width varies from 2 feet to 6 feet. The vein quartz is stained with copper oxides and shows considerable hematite and some free gold associated with chalcopyrite and bornite. Development consists of 4 tunnels at different elevations driven on the vein. These tunnels vary in length from 200 to 600 feet. From lower tunnel, there is a jig-back aerial tram to bin with a capacity of 25 tons. Ore was loaded into trucks and hauled to Sunrise mill in Pinto Basin for treatment. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 79.

Trio Group. See page 437.

Uncle Sam Mine. It comprises 5 claims situated in the Goldstone mining district, 2 miles southeast of Goldstone and 33 miles north of Barstow, in sec. 33, T. 14 N., R. 1 E., S. B.; elevation 3500 feet; owner, L. W. Storrs, Los Angeles.

The vein occurs in schist and clay shales; strike northwest, dip 60° NE.; width 2 feet. Development consists of shaft sunk on the vein to a depth of 110 feet, with levels at 50 and 100 feet, and about 500 feet of drifts.

Mine equipment consists of hoist and compressor. Ore was hauled by truck a distance of 5 miles to the Reward mill which has a capacity of 20 tons per 24 hours. The mill was purchased from the Reward Mining Company.

Mill equipment consists of 25-ton ore bin; 6-inch by 8-inch Blake type crusher; 3-foot by 4-foot ball mill, amalgamation plates and 2 K & K flotation machines. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 80-81.

Valley View Mine. It comprises 12 claims situated on ridge near the south end of Castle Mountains, in the Hart mining district, in sec. 24, T. 14 N., R. 17 E., S.B., 12 miles southeast of Ivanpah, a station on the Union Pacific Railroad; elevation 5000 feet. Owner is John Couch, Needles, California; under lease and option to W. W. Hartmann, Los Angeles. C. H. Chandler is manager.

A series of roughly parallel veins occurs in a rhyolite flow which forms the ridge on which the mine is located. The veins are 3 to 5 feet in width, strike a few degrees east of north and dip steeply to the west. In some instances, the country rock between the veins has been mineralized up to 40 feet in width, making low-grade ore. The vein filling is quartz and altered rhyolite. The gold is very fine, all free.

Development consists of a vertical shaft 200 feet in depth, with levels at 50-, 100-, and 200-foot horizons. One hundred feet northeast of this shaft is an old shaft 50 feet deep which is connected with 200-foot shaft by a stope to the surface. The stope is about 20 feet long by 12 feet wide. There are several short raises and one from 100-foot level to a stope at the surface. The ore is mined across some 40 feet in width.

Mine equipment consists of hoist and compressor driven by diesel engine.

Mill: The cyanide plant has a capacity of 50 tons per 24 hours. Ore from mine to 1-inch grizzly to jaw crusher to 50-ton bin, then ten 1500-pound stamps, crushed to 3 mesh, then to 4-foot by 5-foot Marcy ball mill, in closed circuit with Dorr duplex classifier, to riffled launders to 3 Devereaux agitators, pumped to three 20-foot Dorr thickeners. Counter current decantation to zinc dust precipitator. Ten men were employed.

Vanderbilt mine, comprising 18 patented claims, is in the Vanderbilt mining district, 4 miles east of Ivanpah, in sec. 3, T. 14 N., R. 16 E., S. B.; owner, Allen G. Campbell Estate, Leland P. Reeder, agent, Beverly Hills Realty Company, 400 North Beverly Drive, Beverly Hills, California. The property was formerly leased to Atascadero Mining Company, Oscar L. Willett, president, then at 824 W. M. Garland Building, Los Angeles; J. E. Chilberg, superintendent.

A series of parallel veins occur in the granite, strike N. 70° W., dip 60° N. Average width of veins about 8 feet in the shoots, average 0.67 ounces gold per ton. The Gold Bar lode is developed by three shafts; the working shaft is 425 feet deep, sunk on the vein.

The lessee mined and milled an ore shoot which had been developed by former operators. This shoot was 250 feet long by 8 feet wide on the 200-foot level. The mine was allowed to cave after the developed ore was removed.

A 25-ton flotation plant was erected on the property and operated during the years 1934 and 1935. During 1934 also, 18 cars of ore were shipped to the Midvale, Utah, smelter which averaged $25.00 per ton in gold. The production of the mine during this period amounted to approximately $80,000.00.

Bibl.: State Mineralogist's Reports XI, pp. 367-368; XII, pp. 235-237; XIII, p. 329; XV, p. 816; XXVII, pp. 317-319.

Vontrigger Mine. See page 438.

Vulcan Mine (McClintock) (gold-copper). It comprises 6 claims situated on the northwest slope of Ship Mountains, in sec. 11, T. 5 N., R. 15 E., S. B., 2½ miles southeast of Siam, a station on the Santa Fe Railroad; elevation 1600 feet; owner, Helen C. King, 1030 South Magnolia Street, Los Angeles; under lease to Vulcan Mining Company, Leon O. Compton and H. I. Schuyler, Cadiz, California.

The property was located in 1898 by McClintock. It has been worked off and on to date. From 1935 to 1937, it was under lease to Funk Brothers and H. J. Jackson, Ludlow, California. During this period the production was $50,000 in gold, the ore being mined from the 100-foot level to surface. Ore shipped is reported to have averaged $40.00 per ton in gold. From February 1941 to February 1942, the property was under lease to Rashly, Inc., William M. Dowsing, president; R. C. Aurand, secretary, Santa Monica, California. They shipped 1500 tons of ore to American Smelting & Refining Company's smelter, Hayden, Arizona. Average value of ore shipped was stated to be $9.00 per ton in gold. They also shipped 1200 tons of tailings which is reported to have averaged from $5.00 to $7.50 per ton in gold. During 1942, Vulcan Mining Company shipped 800 tons of ore to American Smelting & Refining Company's smelter, Hayden, Arizona. Shipments carried the following values: Gold 0.345 ounce, silver 0.12 ounce, copper 0.21 percent, silica 70 percent, alumina 10 percent, iron 5.1 percent; total value $11.54 per ton.

The gold vein occurs in quartz diorite; strike N. 10° E., dip 80° E.; width 8 feet to 12 feet. In the hanging wall of the gold vein and parallel to it, is a copper vein which occurs on the contact of quartz diorite and limestone. Limestone is the hanging wall, quartz-diorite the footwall. The copper vein has the same general strike as the gold vein and is from 6 feet to 12 feet in width. The copper vein carries from 2 to 3 percent copper and $6.00 in gold.

Development consists of two vertical shafts. South shaft is 175 feet deep and 150 feet north of this shaft, the north shaft has been sunk to a depth of 500 feet. The present mining and development work is being done from the south shaft. On the 50-foot level drift 150 feet north to north shaft and 125 feet south; on the 100-foot level drift 285 feet south, of which 100 feet was on the vein and 125 feet north on 150-foot level, drift north 150 feet to north shaft; on 175-foot level drift north 25 feet. From 100-foot level to surface, the gold vein has been stoped both north and south of shaft. Copper vein is stoped from the 150-foot level to 50-foot level.

Mine equipment consists of 12-horsepower Thomas hoist (12 inches by 12 inches); Ingersoll-Rand compressor; air drills; cars; and 3-ton truck. Idle.

Iron

Large deposits of iron ore occur in the desert regions of San Bernardino County, and these deposits are now of commercial importance because of the construction of the iron and steel plant at Fontana by the Kaiser Company, Inc. The blast furnace was blown in December 30, 1942, has a capacity of 2500 tons of iron ore and will produce 1200 tons of pig iron per 24 hours. There are also six open-hearth furnaces having a capacity of 185 tons each. The first operation of the open-hearth furnaces was made on May 14, 1943. The operation of the iron

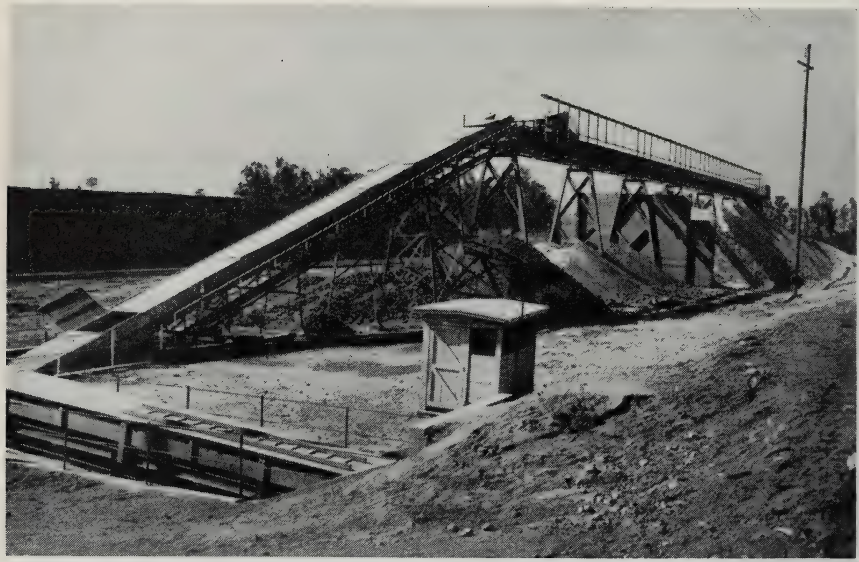

FIG. 6. Iron ore and flux (clay and limestone) stockpile at Kaiser Company, Inc. steel plant at Fontana. *Photo by Walter W. Bradley.*

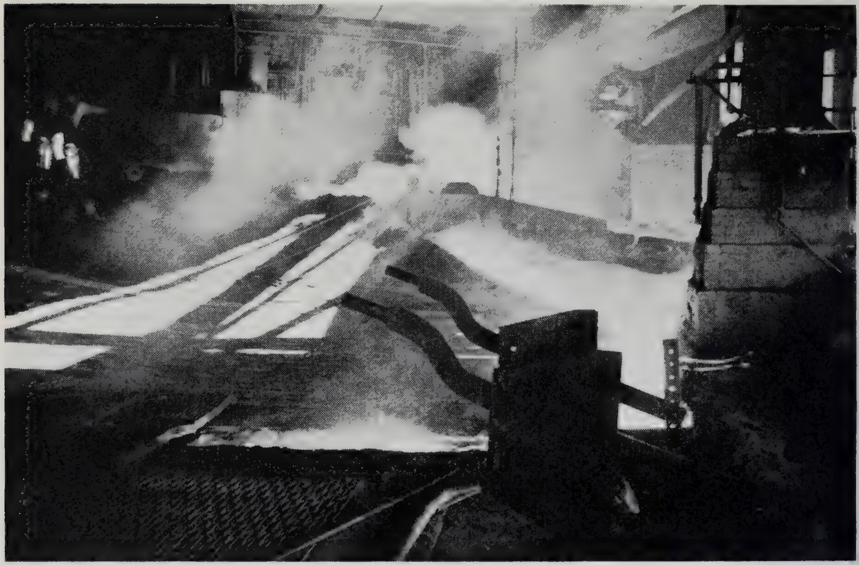

FIG. 7. Tapping the blast furnace at Fontana plant of Kaiser Company, Inc. *Photo by Walter W. Bradley.*

and steel plant has created an interest in the development of the iron deposits throughout the county.

The iron-ore shipments in California during 1942 totaled 94,092 net tons, valued at $344,062.00, and the largest production of iron ore was from three properties in San Bernardino County. The above was the largest annual output in both amount and value ever reported in this state. The ore mined during the year was hematite, some of which went to the stockpile at the new steel plant at Fontana, and the remaining tonnage of ore went to the cement plants located in southern California.

The principal iron deposits are the contact replacement type that occur at or near the contact of an intrusive igneous mass with sedimentary strata, usually dolomitic limestone. For detailed descriptions of these different deposits, see U. S. G. S. Bull. 285, p. 198; U. S. G. S. Bull. 430, pp. 228-239; State Mineralogist's Reports IX, p. 235; XV, pp. 817-821; XXVII, pp. 333-337; Bull. 38, p. 299.

Bessemer and Western iron mines (Iron Mountain) comprises 7 patented lode claims, situated on Iron Ridge, near Bessemer basin in the Lava Bed mining district, in secs. 27 and 28, T. 6 N., R. 4 E., S. B., 18 miles southeast of Newberry, a station on the Santa Fe Railroad. Elevation, 3000 to 3880 feet. Owner, Southwestern Ore Company, Union Oil Company of California, 617 West 7th Street, Los Angeles; under option to the California Iron and Minerals Company, Harry L. Brown, president; Allison Jones, secretary; Edward Morris, consulting engineer and manager, 806 Trans-America Building, Los Angeles. The company has located 39 claims adjoining the Bessemer group on the south, known as the Western Iron group of claims. Three veins of hematite and magnetite occur on the Bessemer group. The vein on Bessemer No. 1 claim occurs on the contact of dolomite and granite; the dolomite being on the north and the granite on the south. The vein strikes northeast, dips 40° SE. The outcrop on the surface can be traced for 400 feet, is from 50 to 100 feet in width, and has an average thickness of 30 feet. Developed by open cut, 100 feet in length, and a tunnel, 50 feet in length; also shafts, 30 to 50 feet in depth.

About 600 to 800 feet northeast of the Bessemer iron deposit are the *Dick Turpin* and *Raven* iron-ore bodies which are separated by 150 feet of granite, with dolomite on the north. The veins are nearly parallel; strike N. 60° to 70° W., and are from 30 to 150 feet in width, and about 400 feet in length. The ore is hematite and magnetite. Analysis: Iron, 60 percent; silica, 3.6 percent; sulphur, 0.06 percent; phosphorus, 0.04 percent.

On the Western Iron group of claims there are several massive outcrops of iron, located on the ridge across the Bessemer Valley, and about 2 miles south of the Bessemer group. These two iron veins strike northeast, and are roughly parallel, occurring on the contact of granite and dolomite. One exposure is 600 feet in length and 50 feet in width. The other is 400 feet in length by 40 feet in width. The ore is hematite and magnetite, reported to assay 60 percent iron. Three men are employed on location work.

Bibl.: State Mineralogist's Reports IX, p. 235; XV, p. 819; XXVII, p. 335; XXXVI, p. 241; Bull. 38, pp. 299-300.

Black Jack Iron Deposit. It comprises 10 claims situated in the Bristol Mountains, in sec. 24, T. 6 N., R. 12 E., S. B., 9 miles northeast of Amboy, a station on the Santa Fe Railroad. Elevation, 2500 feet. Owner, J. W. Gray, Siberia, San Bernardino County, California. Under option to the Moharvey Minerals Corporation, Paul Hansen, president; William Duggan, secretary; James O. H. Keiser, manager, 257 S Street, San Jose, California.

Five lenses of magnetite occur in dolomite near contact of granite, on the Black Jack No. 1 claim, near the crest of the Ridge. The longest exposure is 65 feet in length, and 25 feet in width. The outcrops occur in an area 200 feet in length, by 100 feet in width. The general strike is north; dip 50° E. Samples taken from the individual outcrops reported an average of 50 percent to 60 percent iron; sulphur, 0.05 percent; silica, 1½ to 3½ percent; no phosphorus. Estimated tonnage, 30,000. Development consists of open cuts on individual lenses. Equipment consists of a Rix Portable Compressor, tractor, and trucks. Fifteen men employed building camp and constructing road to the deposit.

Cave Canyon iron deposit, comprising 6 patented claims, is in the Cave Mountains, a mile north of Baxter, a station on the Union Pacific Railroad, in sec. 12, T. 11 N., R. 6 E., S. B.; owner, California Portland Cement Company, 601 West Fifth Street, Los Angeles. Mining and loading of the ore are done under contract by A. S. Vinnell and Company, 1145 Westminster Avenue, Alhambra, California.

The deposit occurs as a series of lenses along the contact of monzonite and limestone. The strike of this contact is N. 75° E., dip practically vertical. The width of the ore zone, as exposed in the present pit ranges from 35 feet at the west end to 175 feet at the east face. Of this width, it is estimated that one-third is waste, largely in the form of igneous dikes. The east face shows a width of nearly 75 feet, which appears to be all ore. The length of the ore zone is something over 1200 feet. Shipments aggregating 300,000 tons are said to have averaged 56 percent iron. Ore reserves are estimated to be 1,500,000 tons.

The property has been developed by an open pit which is now (June 1943) approximately 1000 feet long, by 35 feet wide at the west end. The face at the east end is 75 feet high. About 400 feet east of the east face a vertical shaft has been sunk to a depth of 150 feet. It is reported that the bottom of this shaft is in ore. Some 200 feet east of the pit a crosscut has been driven south 580 feet. Lenses of ore similar to those in the pit were encountered throughout the length of this crosscut.

The quarry face is drilled with wagon drills and jackhammers. Average shots are said to break about 30,000 tons. Ore is loaded with a Lorraine 40, ¾-yard diesel shovel into a 20-ton Sterling diesel truck and one 10-ton gas truck and hauled about one-half mile to the Union Pacific 16-car spur. Other equipment consists of a Gardner-Denver 365-cubic foot diesel-driven compressor, one D-8 tractor for stripping, one 30 gas tractor. Switching of railroad cars is done by tractor. Eight men working. Shipments run from 30,000 to 60,000 tons per year, depending upon demands of the California Cement Company's Colton plant and the Riverside Cement Company's plant at Crestmore. These shipments are usually made in about 4 months, so as to avoid the extreme heat of summer.

Bibl.: State Mineralogist's Reports XV, p. 818; XXVII, pp. 333-334; Bull. 38, p. 299.

Cave Mountain Iron Deposit. It comprises one claim, known as Arrowhead Lode, situated on the south slope of Cave Mountain, in sec. 20, T. 12 N., R. 6 E., S. B., 7 miles northeast of Dunn Siding, a station on the Union Pacific Railroad, and a mile north of U. S. Highway 91; elevation 1500 feet. A small lens of iron ore occurs on contact of limestone and granite; strike northeast, dip 30° NW. The length of the lens is 100 feet and the width 6 to 8 feet. The ore is high grade hematite. In the early part of 1943, it is reported that six cars of ore were shipped to the Southwest Portland Cement Company, Victorville, California. The ore is reported to assay 60 to 64 percent iron. Idle.

Copper World Iron Deposit. It comprises 6 claims, situated on the west slope of Bullion Mountains, in sec. 22 ?, T. 2 N., R. 11 E., S. B., 16 miles northeast of Twenty-nine Palms; elevation 2600 feet; owners, Arthur C. Becker and L. Stevenson, Los Angeles. A vein of iron ore occurs in quartz diorite; strike N. 40° W., dip 65° SW. The lens of ore is 300 feet in length and 8 to 20 feet in width. About 400 feet north is another small lens of iron ore 40 feet in length by 6 feet wide. The ore is high-grade hematite, reported to assay 65 percent iron. Estimated tonnage is 20,000. Development consists of short tunnels and open cuts. Idle.

Dorris May Iron Mine. It comprises one claim situated on the north slope of the Pinto Mountains, in the Dale mining district, in sec. 19, T. 1 S., R. 13 E., S. B., 4½ miles southeast of Dale Dry Lake, and 4 miles northeast of New Dale. Elevation, 3000 feet. Owner, James Hill, Twenty-nine Palms, California. The property was formerly known as *Eaton gold mine* and worked for gold. On top of the ridge, about 500 feet southeast of the upper tunnel, there is a massive outcrop of hematite and magnetite, 75 feet in length, 20 feet thick and 15 feet above the surface. Between the lower tunnel and this outcrop are several short lenses of iron ore about 40 feet in length and 6 feet in width. Ore occurs in andesite, near contact with monzonite. A tunnel has been driven southeast on a quartz vein 1100 feet, strike southeast, dip vertical; at about 400 feet from the portal, there is a winze 100 feet sunk on the quartz vein; width of vein, 4 feet; also, a crosscut northeast 20 feet, which intersected a small streak of hematite. At 400 feet southeast of the lower tunnel, and 100 feet in elevation above the lower tunnel is an upper tunnel driven southeast 340 feet; at 100 feet from portal cut iron ore being 6 to 12 feet thick. Idle.

Globerson iron mine comprises 2 claims in sec. 15, T. 7 N., R. 3 W., S. B., 4½ miles west of Stoddard's well, and about 15 miles northeast of Victorville. Owner, Nathan Globerson, Alhambra, California. A vein of iron ore occurs in granite; strike N. 65° E., dip 70° NW., width 3 feet. Ore is high-grade hematite, assaying 67 percent iron. Development consists of vertical shaft sunk on the vein to a depth of 20 feet. Shipped 100 tons of ore to Kay-Brunner Steel Products, Inc., of Alhambra, California. Idle.

Iron Age Iron Deposit. It comprises 3 patented lode claims, situated in the Dale mining district, in sec. 29, T. 1 S., R. 13 E., S. B., 4 miles northeast of New Dale, and 45 miles by road south of Amboy, a station on the Santa Fe Railroad. Elevation, 2250 feet. Owner, Marcus Pluth Estate, Los Angeles, California. Near the summit of a large hill and also on the south slope are 4 large veins of iron which strike north to northeast. The veins occur in an augite granite porphyry. The largest of the veins is 400 feet in length and 15 to 100 feet wide. The vein is irregular and has several large branches. The second largest vein is 350 feet in length and 10 to 40 feet in width. On the northwest end of the hill there is a vein 5 to 15 feet wide, and about 350 feet in length. There are also a number of smaller veins between the above-mentioned veins. The ore is hematite and magnetite, the magnetite being oxidized to hematite. The ore is high grade, assaying 60 percent iron, 3.7 percent silica, 0.06 percent sulphur, and 0.04 percent phosphorus. Development work consists of shallow shafts and open cuts. The deposit is estimated to contain 1,000,000 tons of commercial ore. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 818-819; XXVII, p. 334; Bull. 38, p. 299; U. S. G. S. Bull. 340, pp. 228-239.

Iron Hat iron deposit comprises 7 claims, situated in Marble Mountains, in SW¼ sec. 21, T. 6 N., R. 14 E., S. B., 4½ miles north of Chambless Station on U. S. Highway 66, and 7 miles north of Cadiz, a station on the Santa Fe Railroad. Elevation about 4000 feet. Owner, Thomas Schofield, Amboy, and Arthur Doran, Barstow, California; under lease to Riverside Cement Company, 621 South Hope Street, Los Angeles. Iron ore occurs on contact of dolomitic limestone and diorite. The iron vein outcrops in the canyon; strike northwest, dip 80° NE., width, 10 feet. This vein merges with a massive iron outcrop on top of the mountain to the north of the canyon and is from 40 to 50 feet in width. There is another outcrop to the northeast from which some 2000 tons of ore was mined and shipped to the Llewellyn Iron Works, Los Angeles. The ore is black hematite, reported to assay from 60 to 65 percent iron. Estimated tonnage is 25,000. Development consists of two tunnels; one 40 feet in length, the other a crosscut tunnel 100 feet in length; also, a number of open cuts on different outcrops.

Bibl.: State Mineralogist's Report XXVII, p. 334.

Iron Mountain Iron Deposit. It comprises 6 patented claims, situated on the south slope of the Avawatz Mountains, in secs. 11, 12, 13, and 14, T. 15 N., R. 6 E., S. B., 10 miles west of Silver Lake. Elevation, 2200 feet. Owner, Colorado Fuel & Iron Company, Pueblo, Colorado. A massive outcrop of iron occurs on contact of dolomitic limestone and granite. The iron-ore outcrops can be traced for a distance of 4500 feet and are from 50 to 500 feet in width. Strike of the outcrop is north. The ore is hematite and magnetite, reported to assay 50 to 60 percent iron. Development consists of shallow shafts and short tunnels made along the outcrop. Estimated tonnage of commercial ore is 12,000,000. Idle.

Bibl.: State Mineralogist's Report XV, p. 820; XXVII, p. 335.

Kingston Mountain Iron Deposit. It comprises 6 patented claims, situated in Kingston Mountains, T. 19 N., R. 11 E., S. B., 25 miles northeast of Valjean, a station on the Tonopah and Tidewater Railroad. Elevation, 6000 feet. Owner, Dorsey E. McLaughlin, San Francisco, California. The ore is hematite and magnetite which occurs near contact of monzonite and limestone. The Pacific Coast Steel Company, San Francisco, purchased the property from Charles A. Beck of Good Springs, Nevada. This company thoroughly prospected the deposit with

Diamond drills, and their engineer estimated that the deposit contained 12,000,000 tons of 50 percent iron ore. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 335; Bull. 38, p. 300.

Nigger Head Iron Deposit. It comprises 1 claim, situated in the Dale mining district in the canyon $1\frac{1}{2}$ miles southeast of Ivanhoe mine, in sec. 21 ?, T. 1 S., R. 13 E., S. B., 5 miles northeast of New Dale. Elevation, 2000 feet. Owner, Henry Olsen, Twenty-nine Palms, California. The iron ore occurs as hematite and magnetite in quartz diorite. The strike of the ore outcrop is northwest, the dip vertical. In the canyon there is an outcrop of iron ore, 75 feet in length, 6 feet in width; about 900 feet northwest of this outcrop is an exposure 100 feet in length by 6 feet in width. Development consists of 80-foot shaft, open cuts and short tunnels. Ore is reported to assay 60 percent iron. Idle.

Ship Mountain Iron Mine. It comprises 7 claims, situated on the west slope of Ship Mountains, in sec. 11, T. 5 N., R. 15 E., S. B., $2\frac{1}{2}$ miles southeast of Siam, a station on the Santa Fe Railroad. Elevation, 3500 feet. Owner, Earl W. Paul, Upland, California.

A vein of hematite occurs on the contact of diabase and dolomitic limestone, with diabase as the hanging wall and dolomite as the footwall. The strike of the vein is north, dip 30° E., width 6 to 10 feet. It can be traced on the surface for about 4500 feet. Three lenses of iron ore are exposed along the outcrop. The largest lens is 150 feet by 6 feet in thickness, which was developed by the incline shaft, and stoped out to the 120-foot level. The south lens of iron ore is about 1000 feet south of the incline shaft and consists of two veins with horse of diorite between the veins. The veins have an average width of 6 feet and are developed by open cut on the east vein, and tunnel driven south 30 feet about 40 feet below the outcrop on the west vein. The other outcrop is about 2500 feet north of the incline shaft. The vein has a width of 8 feet and is developed by a shaft 30 feet in depth and a crosscut tunnel 30 feet in length. The main lens is developed by an incline shaft 525 feet in depth. On the 75-foot level south of the shaft, stope 150 feet in length, stoped to the surface. This stope extends to the 120-foot level south. On the 195-foot level north, stope 75 feet in length, 8 feet high, with 3 feet of high-grade hematite in face of stope. On 320-foot level north, about 20 feet north of shaft, stope 40 feet in length, with 3 feet of ore in face. On 395-foot level north, drift north 30 feet, with 3 feet of ore in face. On 450-foot level north, drift 24 feet north exposes 5 feet of ore. At the bottom of the shaft, crosscut driven east 100 feet. One thousand five hundred tons of iron ore, reported to average 60 percent iron, was shipped in 1918 to the Southern California Iron Company and to the Llewellyn Iron Works. No equipment was on the property; track and mine timbers have been removed and underground workings are in bad shape. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 335-336.

Van Buren group of three claims is in sec. 12, T. 5 N., R. 4 E., and sec. 7, T. 5 N., R. 5 E., S. B., in the Lava Bed mining district, about 23 miles southeast of Newberry, a station on the Santa Fe Railroad. Owners, Hattie Lou Moss, 1833 South Barrington, West Los Angeles; Norton Shaw, 1416 Soto Street, Los Angeles; W. J. Thornton, 704 8th Street, Alhambra, and J. H. Purvis, 700 Virginia Road, Covina, California.

The rocks exposed on this property are granite and limestone. The deposit occurs at this contact, which strikes N. 35° E., and dips east.

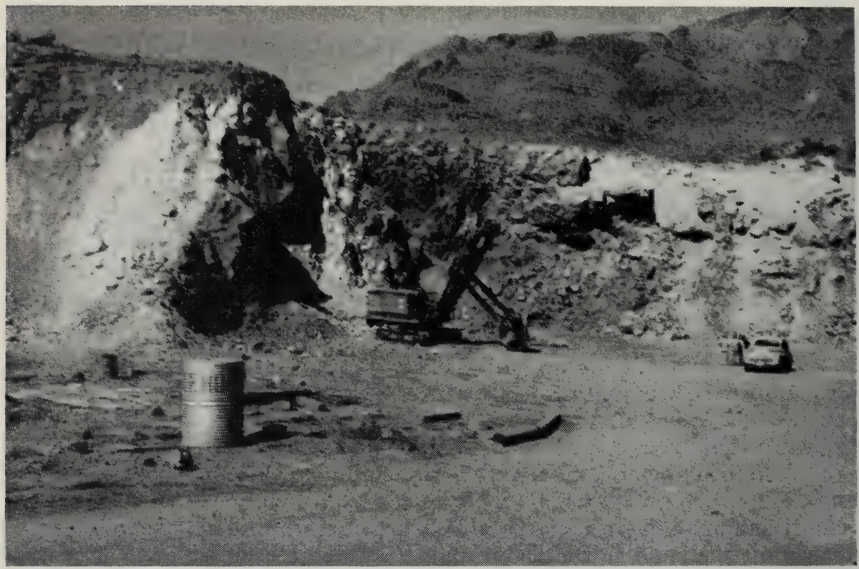

FIG. 8. A bench in open pit of Vulcan iron mine of Kaiser Company, Inc., near Kelso. *Photo by Walter W. Bradley.*

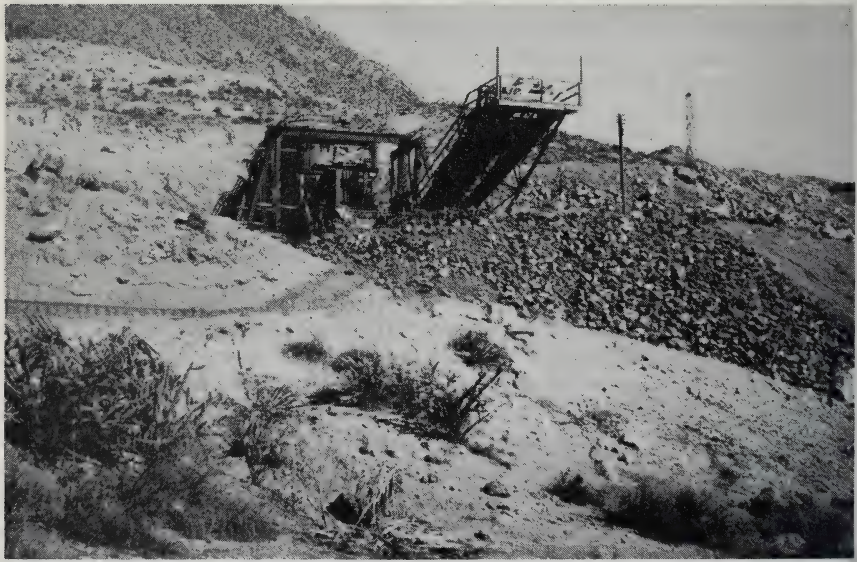

FIG. 9. Ore bin and truck-loading belt at Vulcan iron mine. *Photo by Walter W. Bradley.*

There are two outcrops of iron ore on separate spurs from the main mountain. These outcrops are about 1200 feet apart. The northeast outcrop, which is on top of the ridge, is hard black hematite. It consists largely of float scattered over an area about 40 feet wide by 80 feet long. Where opened by a shallow side-hill cut just below the top of the ridge, the ore is a normal red hematite, which is said to contain 66 percent iron. Sufficient work has not been done here to even determine its width. About 1200 feet southwest from this outcrop is a similar one in a saddle on the other ridge. This is lenticular and shows evidence of faulting where it grows narrow at its northern end. On the side of the mountain between these ridges, several very shallow cuts show indications of ore along the general strike, but more work would have to be done to prove definitely its continuity. Idle.

Vulcan iron mine, comprising 7 claims, is in sec. 25, T. 10 N., R. 13 E., S. B., on the north slope of the Providence Mountains, 9 miles south of Kelso, a station on the Union Pacific Railroad. This property has been purchased from C. Colcock Jones by Kaiser Company, Inc., Henry J. Kaiser, president; offices, Latham Square Building, Oakland, California; local office, Fontana, California; Robert E. Tally, superintendent; George Havas, chief engineer.

This iron deposit occurs in dolomitic limestone at its contact with quartz monzonite. The deposit strikes eastward. The contact, forming the western limit, dips 70° W. The monzonite occurs at the west end. The limestone envelopes the other three sides. The deposit is approximately 300 feet wide by 1000 feet long and is estimated to contain 2,500,000 tons of ore averaging about 51 percent iron.

The deposit is being developed by an open cut and two benches. The open cut which is at the base of the mountain, is some 400 feet long by 300 feet wide by 60 feet deep. The west end of this cut is at the contact. The east end of the cut rises about 60 feet to the floor of the lower bench which is approximately 50 feet wide by 300 feet long. The face of this bench is some 40 feet high. The upper bench, 60 feet above, is 40 feet wide by 150 feet long. The length is now being extended to the north. From this bench, the east end of the deposit will be mined from this level to the top, a vertical distance of 127 feet.

The benches are drilled with 2½-inch Sullivan rotary and 9-inch churn drill holes to 10 feet below the bottom. The holes are blasted with 60 percent dynamite. The average shot breaks 30,000 tons. Ore is loaded into 22- and 33-ton trucks by two 2½-yard power shovels. It is hauled to a hopper at the level of the lower bench, then fed to 42-inch by 48-inch jaw crusher, crushed to minus 8 inches and then falls onto a stock pile. An inclined 40-inch conveyor, in a tunnel under the stock pile is fed by an apron feeder and empties directly into trucks. These trucks haul 9 miles over an oiled road to a stock pile on a siding at Kelso; from stock pile through apron feeder to 40-inch belt equipped with automatic weighing device, direct to railroad cars. They are shipping 2400 tons daily to the Iron & Steel Plant of Kaiser Company, Inc., Fontana, California.

Power is supplied by 280-horsepower Fairbanks-Morse diesel engine, direct-connected to 186 K. W. generator. A modern camp to house 65 men has been built. One hundred men are employed, 35 families living in trailers at Kelso.

Bibl.: State Mineralogist's Reports XV, pp. 820-821; XXVI, p. 264; Bull. A.I.M.E., Sept. 1915, p. 1889; E. & M. J. April 17, 1909.

Lead-Silver and Zinc

Alta Mine (Riggs) (lead-silver). It comprises 4 claims situated on the northwest slope of Silurian Mountains, in sec. 6, T. 16 N., R. 9 E., S. B., $1\frac{1}{2}$ miles east of Riggs, a station on the Tonopah & Tidewater Railroad; elevation 1800 feet; owner, W. B. Turner, Long Beach, California; under lease and option to C. F. Robbins, Long Beach, California.

The ore occurs in irregular lenses along a series of parallel fault fissures which strike north and also at intersections of east-trending fissures, with north-trending fissures in the limestone. The ore mined was native silver, galena, cerussite, and chloro-bromides of silver. The main north-trending fissures have a porphyry filling, heavily stained with iron and manganese. The width of ore mined was from 12 inches to 4 feet. The north-trending fissures dip 65° to 70° W. and the east-trending fissures dip 70° S. Developed by three tunnels. The lower tunnel is driven as a crosscut N. 35° E. to north-trending fissure, a distance of 150 feet. About 60 feet in elevation above this tunnel, a tunnel has been driven N. 35° E. 165 feet to north-trending fissure; at 45 feet north of portal of tunnel drift east 120 feet on east-trending fissure. At 50 feet in elevation above this tunnel, the upper tunnel is driven N. 35° E. 25 feet, intersecting east-trending fissure, with a drift 60 feet east and 100 feet west. Above the upper tunnel, ore has been stoped out to the top of the mountain. From the above-mentioned workings there was an aerial tramline 1500 feet in length to bins near camp. It is reported that the production from the property was $200,000.00 in silver. In 1939, at lower elevation, a crosscut tunnel was driven 1700 feet in length, reported to have intersected a fissure 6 feet in width. The ore developed in this tunnel is reported to carry 11 percent lead and 5 ounces in silver per ton. Three men are employed.

Bibl.: State Mineralogist's Reports XVII, p. 359; XXVII, p. 340.

Anaco (Red Raven) mine,[8] comprising 12 claims, in secs. 30, 31, T. 7 N., R. 5 W., is about 5 miles north of Adelanto and 1 mile west of San Bernardino-Randsburg highway; elevation about 3000 feet; owner, F. A. Rogers, Los Angeles; under option to J. T. Pierson.

A thick bed of dark crystalline limestone has been intruded by a series of igneous dikes, evidently offshoots from the granitic rock which marks the eastern boundary of the limestone. Strike of the limestone is N. 25° W., dip 75° to 85° W. The ore forms in irregular lenses along these contacts. The ore is sphalerite, zinc sulphide.

Development consists of a 100-foot vertical shaft and a 70-foot shaft some 300 feet apart. Idle, but it is the intention of the owners to start development work in the near future.

Avawatz Crown Mine. It comprises 6 patented claims situated in the Silver Lake district on the south slope of the Avawatz Mountains, 7 miles northwest of Silver Lake, a station on the Tonopah & Tidewater Railroad, in sec. 26, T. 16 N., R. 6 E., S. B.; elevation 3500 feet; owner, Avawatz Consolidated Mines Company, Alvin B. Carpenter, president, Los Angeles. Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 359-360; XXVII, p. 341.

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[8] For a more complete description of this property see: Tucker, W. B., and Sampson, R. J., op. cit., pp. 340-341.

Bell Gilroy Mine. It comprises 3 claims situated in the Trojan mining district on the east slope of the Providence Mountains, 22 miles northwest of Fenner, a station on the Santa Fe Railroad, in sec. 9, T. 10 N., R. 14 E., S. B.; elevation 4350 feet; owner, Hamp Williams, Randsburg, California. The ore consists of argentiferous galena deposited in a silicified limestone breccia, near contact with intrusive quartz monzonite. Idle.

Bibl.: State Mineralogist's Reports XVII, p. 360; XXVII, p. 341.

Bonanza King Mine. It comprises 9 patented claims situated in the Trojan mining district, on the east slope of the Providence Mountains, sec. 31, T. 10 N., R. 14 E., and sec. 6, T. 9 N., R. 14 E., 25 miles northwest of Fenner, a station on the Santa Fe Railroad; elevation 4200 feet; owners, Hall, Rawitzer & Co., Acton, Massachusetts.

Irregular lenticular orebodies in carboniferous limestone occur along a series of parallel north-trending fissures. These fissures are near the contact of limestone and monzonite and run parallel to the contact. The ore occurs as lead carbonate, chloride of silver, and chloro-bromide of silver, with a small percentage of galena. The orebodies worked were 4 to 20 feet in width. Developed by vertical shaft 540 feet in depth. Idle.

Bibl.: State Mineralogist's Reports X, p. 532; XIII, p. 606; XV, p. 827; XVII, pp. 360-361; XX, p. 198.

Bullion mine, comprising 12 claims, is in the Bullion mining district, on the east slope of the Ivanpah Mountains, 10 miles north of Cima, in sec. 3, T. 15 N., R. 14 E., S. B. It is just east of the New Trail mines; owner, Joseph Johnson, Cima, California.

It is an old property. The ore, which is lead carbonate carrying silver, occurs in limestone. Development consists of a shaft 150 feet deep. Idle.

Burcham Mine (Total Wreck). The property comprises 21 unpatented mining claims, consisting of 415 acres, is located in the Calico mining district, on the south slope of the Calico Mountains, in secs. 16 and 21, T. 10 N., R. 1 E., S. B., 12 miles northeast of Barstow, 5 miles northwest of Yermo; elevation 1800 to 2850 feet; owner, Dr. Rose L. Burcham, Alhambra, California. The property is under lease and bond to Burcham Mines, Inc., H. S. Kimball, president; I. S. Betts, secretary; Granville Moore, consulting engineer and manager, Los Angeles.

The rocks of this and the adjoining Calico district, comprise a closely related series of Tertiary flows, and associated tuffs, conglomerates, or breccia. They are cut by numerous dikes and irregular intrusions of rhyolite and other rocks. The oldest and most important ore-bearing formation is an interbedded series of rhyolite flows, including breccias, massive tuffs, porphyritic flows, banded flows, and water-laid deposits of several kinds of volcanic debris, including well-laminated silts. Faulting is widespread throughout the entire district. However, only two of the fractures are exposed to any extent by the underground workings in the Burcham mine, limited to some 800 feet along the strike of each of the two fractures. All orebodies developed on the property are localized along these two faults and their branches. The development has been confined mainly to two veins within the two fractures, known as the Burcham vein and the Mulcahy vein.

The Burcham vein strikes N. 70° W. and dips 35° to 65° S.; width 3 feet to 7 feet. The valuable minerals in this vein are gold, silver, and lead. The gold is finely divided and disseminated throughout the quartz, and iron is present as hematite and limonite. Lead occurs as lead carbonate and occasional bunches of galena. Silver occurs as silver chloride. The Mulcahy vein is 300 feet to 500 feet north of the Burcham, and the principal mineralization is in gold and silver. The Mulcahy vein strikes N. 45° W. and dips 65° S.; width 4 feet to 30 feet, with high-grade streak on footwall; width 26 inches, with mineralization extending into hanging wall for a width of 15 feet to 30 feet. Ore shoot developed on this vein is 600 feet long, average width 20 feet; reported to have an average $6.50 per ton in gold and silver.

Development consists of crosscut tunnel N. 15° E., 512 feet in length. At 104 feet from the portal, intersected the Burcham vein, with drift on the vein 200 feet southeast and 640 feet northwest. The Burcham vein where intersected by crosscut tunnel had a total width of 90 feet. A shaft, the collar of which is located at the surface directly above the southeastern side of the intersection of the vein by crosscut tunnel, is sunk to a depth of 60 feet below tunnel level, all in ore. Total depth of shaft is 150 feet. Two raises have been put up to the surface on the Burcham vein. One is located northwest of crosscut, the other near face of northwest drift.

Three winzes have been put down on the Burcham vein to a depth of 100 feet below tunnel level about 200 feet apart in the northwest drift and crosscuts are being driven to determine width of orebody. In this development work bunches of sulphide ore have been encountered, being galena associated with sphalerite. The Mulcahy vein was intersected by crosscut tunnel at 410 feet north of tunnel, with drift northwest on the vein 500 feet and southeast 240 feet. Where crosscut tunnel cut the vein, the width of the vein is 30 feet. The high-grade streak mined on this vein has a width of 26 to 30 inches, is reported to average $15.00 per ton. Total amount of underground workings is about 10,000 feet.

Equipment consists of 2 compressors, one of 360-cubic feet capacity, driven by 75-horsepower motor, the other of 160-cubic feet capacity. Electric power is secured from Southern Sierras Power Company. Water is secured from well on the property below mine, depth of well being 250 feet. The water is pumped with Triplex pump through 2½-inch pipeline to storage tank; lift 218 feet. Idle.

Bibl.: State Mineralogist's Reports XI, p. 343; XVII, p. 351; XXVII, pp. 358-359; XXXVI, pp. 59-61.

Cactus Flat Mine (Morongo Mine). It comprises 4 claims situated on the east slope of San Bernardino Mountains, in Black Hawk mining district, in sec. 19, T. 3 N., R. 2 E., S. B., 14 miles southeast of Lucerne Valley P. O. and 35 miles southeast of Victorville; elevation 5500 to 6000 feet; owner, Mrs. Laura B. Walbeck, Big Bear Lake, California.

On ridge north of Cactus Flat a porphyry intrusive dike cuts the limestone beds. The dike strikes N. 70° W., dip 50° S. and is from 6 feet to 8 feet in width. The porphyry is mineralized with lead carbonate and galena. On the footwall side there is a streak of galena 12 inches to 18 inches in width. A tunnel has been driven east along this streak of ore about 50 feet. One hundred feet west of the tunnel a shaft has been sunk to a depth of 75 feet in the porphyry dike. On the south slope of the ridge, about 600 feet in elevation below upper workings, a crosscut tunnel has been driven 550 feet north in marbleized limestone but has not intersected the porphyry dike. West of this tunnel, there is another tunnel driven N. 50° W. 90 feet along contact of granite and limestone. At 35 feet from portal, a winze has been sunk on contact to depth of 15 feet. The vein material is mineralized with limonite and hematite, with some copper oxides. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 503; XXVII, p. 353.

Calico-Odessa Group of Mines. This group of mines consists of a number of former producing properties, known as the *Baltic, Bismark, Garfield, Odessa,* and *Thunderer,* consolidated under one ownership, known as the Calico-Odessa group. The holdings comprise 21 patented claims, totaling 300 acres, with 23 claims held by location, making a total of approximately 500 acres situated in secs. 10, 11, 14, 15, and 23, T. 10 N., R. 1 E., in Calico mining district, 5 miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 2600 feet to 2800 feet; owner, Mrs. J. R. Lane, Yermo, California.

The principal development work and the main production of ore has been on the Bismark, Garfield and Thunderer, and Odessa group of mines. The principal orebodies developed occurred along a series of faults in a rhyolite tuff. On the Bismark-Occidental group of claims are two faults. The Bismark fault strikes northward, dips 30° W. Chlorides and chloro-bromides of silver occur in irregular fractures and joint planes in a mineralized zone along this fault fissure. The ores are cerargyrite and embolite, with a little chrysocolla, in a gangue of barite. The Occidental fault strikes N. 15° E., dips 35° W., and the orebodies occur in a mineralized zone along this fault fissure.

The Garfield-Thunderer is situated on a ridge west of Odessa Canyon. The formation in which the mineralization occurs is a violet-brown liparite. The principal orebodies developed and mined occurred along the Garfield fault which strikes northwest and dips 75° SW. The silver ores occurred in a brecciated and fractured zone south of the fault in rhyolite tuff. The argentiferous minerals are cerargyrite and embolite in a gangue of barite. The main production of silver ore came from this group of claims. Development consists of two tunnels. The lower Garfield tunnel is driven along the Garfield fault for a distance of 4000 feet. One hundred feet in elevation above this tunnel is the upper tunnel driven along the fault for a distance of 2500 feet. Large chambers of ore were mined through these tunnels in a fractured zone; on both sides of the fault, the different stopes show lengths of 300 feet, widths of 40 feet.

The Odessa mine is situated on a ridge west of Odessa Canyon, at an elevation of 2700 feet. Chlorides and chloro-bromides of silver are found in seams and fractures along the Odessa fault which strikes N. 40° W. and dips 70° SW. Development consists of the Odessa tunnel which is driven 600 feet on the Odessa fault. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 497; XI, p. 434; XII, pp. 608-609; XVII, pp. 362-363; XXVII, pp. 343-345; XXXVI, pp. 243-244.

California-Hercules Mine. It comprises 32 claims situated on the north side of the south fork of Lytle Creek on the southeast slope of the San Bernardino Mountains in secs. 29 and 32 (?), T. 2 N., R. 6 W., S. B., 5 miles southwest of Glen Ranch and 6 miles southwest of Keenbrook, a station on the Santa Fe Railroad; elevation 4500 feet; owner, Roy Kitching, 686 Elmira Street, Pasadena, California.

On the north side of the canyon, there are three beds of limestone which are separated by 200 to 400 feet of felsitic intrusives. Irregular deposits of lead and zinc ore occur along fractures in the felsite and also on contacts with the limestone. The general strike of the vein is northwest, dip 30° E. The ore is lead carbonate, sphalerite, and galena, carrying some silver.

Development consists of open cuts, short tunnels, and shallow shafts made at different elevations along the outcrop. A lower tunnel has been driven northwest 350 feet. A large flow of water was encountered along one of the fractures. Installation of an aerial tram to road above the property is planned. Three men are employed.

Bibl.: State Mineralogist's Report XXVII, p. 345.

Carbonate King Mine. It comprises 6 claims situated on the southwest slope of Ivanpah Mountains, in sec. 31, T. 18 N., R. 14 E., S. B., 7 miles west of Roach, a station on the Union Pacific Railroad and 15 miles north of Wheaton Springs Station on U. S. Highway 91; elevation 5500 feet; owner, Mrs. M. W. H. Williams, San Bernardino, California.

The mineralization, consisting of oxides of iron and manganese with lead carbonate, carrying silver, occurs along a fracture and in the bedding planes of dolomitic limestone. Strike of the bedding planes is northwest, dip 45° SW. The mineralized fissure strikes N. 20° E., dip vertical.

Ore developed in upper tunnel was 100 feet in length, with an average width of 4 feet. Three hundred feet in elevation below upper tunnel, a crosscut tunnel was driven N. 20° E. 500 feet. A raise connects this lower tunnel with upper workings. Recently it is reported a discovery of scheelite was made on the property along bedding planes in the dolomite. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 347.

Carbonate King zinc mine * comprises 14 claims known as Crystal Cave group, situated on the western slope of Kokoweef Peak, in the Ivanpah Mountains, in the N½ sec. 4, T. 15 N., R. 14 E. and the S½ of sec. 32, T. 16 N., R. 14 E., S. B., 5 miles southeast of Mountain Pass and 14 miles north of Cima, a station on the Union Pacific Railroad; elevation 5000 feet; owner, Crystal Cave Mining Company, H. C. Moore, president; Herman Wallace, secretary, 3352 Isabel Drive, Los Angeles.

The company is a Nevada corporation, with offices at Las Vegas, Nevada; under lease to W. F. Huston, Mountain Pass, via Nipton, California. Crystal Cave group was located by L. P. Ressler in 1928 but it was not until 1941 that zinc ore was discovered on the property by W. F. Huston, who had a contract to drive a crosscut tunnel to intersect the Kokoweef Cave for the Crystal Cave Mining Company.

The orebody occurs along a fracture or fractures in dolomitic limestone which strike northward, dip 60° W.; width 10 feet to 12 feet. The ore is sphalerite near surface which has been oxidized to hydrozincite and smithsonite, associated with hematite and some cerussite (lead carbonate).

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* See also *Geology and Ore Deposits of the Koko Weef Mountain Area, San Bernardino County, California*, by Arthur Richards and A. L. Brokaw, U. S. Dept. of Interior, Geological Survey, Information Service, Ext. 3726, mimeographed report 34558; fig. 1, *Geologic and Topographic Map, Koko Weef Mt. Area, San Bernardino Co., California*, scale 1″=250′; fig. 2, *Carbonate King Mine, Composite Plan of Workings, Showing Geology of Third Level*, scale 1″=20′; *Geologic Sections, Carbonate King Mine*, scale 1″=20′; *Geologic Section, Koko Weef Mt. Area*, scale 1″=50′; 1944.

Development consists of single-compartment shaft sunk on an inclination of 70° to a depth of 120 feet, with levels at 50, 90, and 120 feet. On the 50-foot level, drift 55 feet north in ore; on 90-foot level, drift 130 feet north in ore; on 120-foot level, crosscut west to orebody.

Ore mined and shipped to Ozark Mining & Smelting Company, Coffyville, Kansas, to December 1942, was about 2000 tons, of 38 to 40 percent zinc with some lead, gold, and silver.

Analysis of ore shipments:

Zinc	38.0%
Lead	1.1%
Iron	4.2%
Silver	10.3 oz.
Gold	trace
Insol.	12.0%
Lime (CaO)	12.0%
H_2O	5.2%

They are now hauling 10 tons per day to government stock pile at Jean, Nevada.

Mine equipment consists of 6-horsepower gasoline hoist; 130-cubic foot compressor and jackhammers; aerial tramway 1100 feet in length from shaft to loading bins. Eight men are employed.

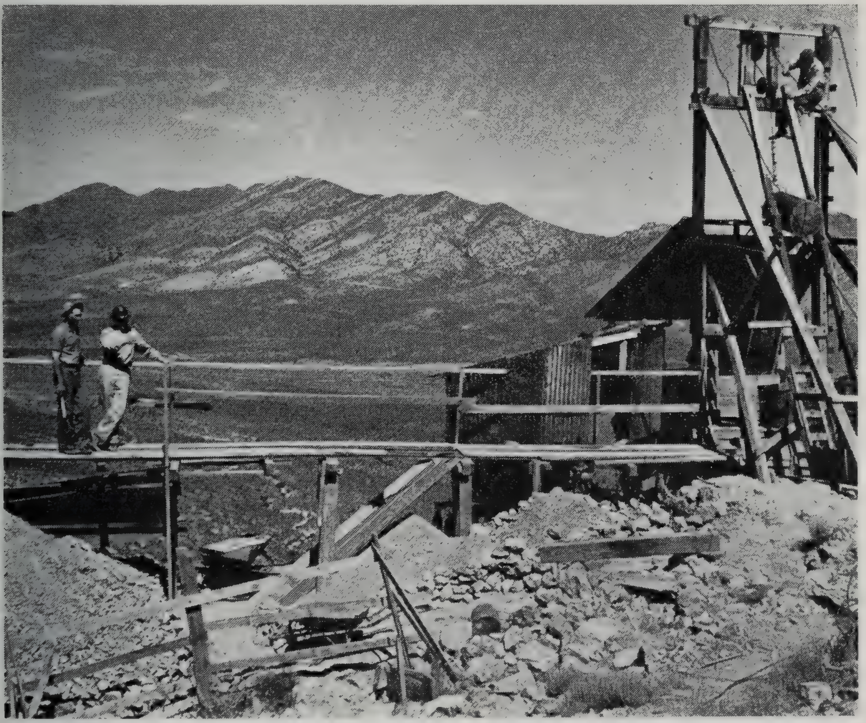

FIG. 10. Head-frame and shaft, Carbonate King zinc mine, 14 miles north of Cima. *Photo by courtesy of Paul Lindau, Los Angeles.*

Cucamonga Zinc Mine (Blew Jordan). It comprises one claim located as Blew Jordan mine, situated at the headwaters of the south fork of Lytle Creek, on the east slope of Cucamonga Peak, in sec. 25, T. 2 N., R. 7 W., S. B., 6 miles west of Glen Ranch, 16½ miles over San Semaine Forest Service Road from the Lytle Creek U. S. Forest Service Ranger Station to San Semaine Flat; from San Semaine Flat over mountain trail 1½ miles in length; elevation of mine 7000 feet; owner, Rowland B. Lyttle, Los Angeles.

The lead-zinc sulphide ore occurs as a replacement deposit on the contact of limestone and granite. The strike is N. 20° W., dip 70° E. The outcrop of garnet-epidote rock can be traced on the surface for a distance of 1000 feet and is 30 feet in thickness. The zinc occurs as a marmatite, associated with galena with coatings of cadmium (greenockite—CdS). Development consists of shallow surface cuts, short tunnels and a shaft 17 feet deep.

Samples taken from open cuts and shaft are reported to carry from 6 to 14 percent lead, 8 to 20 percent zinc, with 5 ounces to 25 ounces silver. One man is employed.

Death Valley mine, comprising 7 claims, is 3 miles east of Cima, a station on the Union Pacific Railroad, in sec. 11, T. 13 N., R. 14 E., S. B.; elevation 4400 feet; owner, Lee Strawn, Cima, California.

There has been no activity at this property since 1931.[9]

Garfield Mine. It comprises 9 claims situated in the Black Hawk mining district on the east slope of the San Bernardino Mountains, in sec. 12 (?), T. 3 N., R. 1 E., S. B., 12 miles southeast of Lucerne P. O. and 33 miles southeast of Victorville; elevation 5000 feet; owner, Garfield Lead & Silver Mines, Inc., Joseph Baumgartner, president; Louis Zimmer, secretary, Bakersfield, California.

The country rock is limestone. The ore occurs as irregular bunches, in the form of cerussite, galena, and wulfenite, along fault fractures in a brecciated limestone. The fault fractures strike northwest, dip 50° NE. Development consists of two tunnels. The upper tunnel is a crosscut tunnel driven N. 30° E. 164 feet, to northwest-trending fissure, with drift 35 feet northwest and 73 feet southeast. The lower tunnel is 400 feet below upper tunnel, driven as a crosscut N. 30° E. 1100 feet in brecciated limestone to intersect fissure developed in upper tunnel level. At 700 feet from portal, there is a drift southeast 550 feet along a fault fracture; no ore developed. In upper tunnel the fault fissure was 8 to 10 feet wide, mineralized with occasional lenses of cerussite, galena, and wulfenite. Small shipments of ore made from the property in 1932 are reported to carry $80.00 per ton in lead and silver. Idle.

Gold Hill claim belonging to Foster Mines Company, E. D. Foster, president, Los Angeles, has been leased to Marty Herbst and associates of Los Angeles. It is 2 miles northwest of the main shaft and the mill on this company's copper property.

The vein occurs in diorite. It strikes north, dips 70° E. and ranges in width from 6 inches to 2 feet. The vein filling is quartz and altered wall rock. The metallic minerals are anglesite (lead sulphate) and cerussite (lead carbonate). Where quartz predominates in the vein filling, the metallic minerals are rarely abundant enough to constitute ore. The ore occurs in lenses the length of which has not been demonstrated, due to lack of lateral development.

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[9] For a complete description of this property, see Tucker, W. B., and Sampson, R. J., op. cit., pp. 348-349.

Development consists of shaft sunk on 75° inclination 55 feet, with drift north 15 feet and south 15 feet. The south face shows about 2 feet of quartz, while in the north face there is about 2 feet of ore.

There is a Rix compressor and gasoline hoist at this shaft.

The ore was hauled 2 miles to the company's mill which consists of 8-inch by 12-inch crusher, elevator to crushed-ore bin, belt feeder to 5-foot by 4-foot ball mill to 2 Plat-O tables.

There is a 600-foot well in the building. Idle.

Ibex or *Arcturus mine* is in the Black Mountains, 16 miles southwest of Zabriskie and 6 miles north of Saratoga Springs, in T. 19 N., R. 5 E., S. B.; elevation 1300 feet. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 821-822; XVII, p. 287.

Imperial Lode Mine (Cave Springs Mining Corporation). It comprises 3 patented claims known as Mammoth Chief, Queen of the Desert, and Meteor; also 3 claims held by location in sec. 35, T. 7 N., R. 5 E., S. B., in the Lava Bed mining district, 9 miles southwest of Lavic, a station on the Santa Fe Railroad; elevation about 4000 feet; owner, Cave Springs Mining Corporation, W. W. Tucker, president; M. S. McLeon, secretary, 1131 Valencia Street, Los Angeles.

The Imperial lode, which can be followed along its outcrop for about 8000 feet, occurs in quartz porphyry, strikes N. 70° W. and dips 70° S.; width 6 feet to 20 feet. A felsitic intrusive dike cuts across the lode at 3500 feet from its west end. This dike follows the hanging wall of the vein for a considerable distance to the west. The lode is quartz, barite, calcite, and manganese. The ore occurs in shoots and bunches in the vein. The principal value of the ore is its silver content, which occurs as chloride and sulphide (argentite), associated with pyrite, chalcopyrite, and iron oxides; also occurs with lead carbonate ores. Some of the lead carbonate ore mined is said to carry as high as 200 ounces in silver. The chloride of silver is found associated with iron and manganese.

The principal development work is on the Meteor, Mammoth Chief, and Desert Queen claims. The Meteor shaft has a depth of 100 feet, with drifts on the 50-foot and 100-foot levels; ore is stoped to surface. For a distance of some 800 feet along the lode are open cuts and shafts, with drifts. The ore mined from these workings is reported to have had an average value of 25 ounces in silver. The reported production from the Meteor and Mammoth Chief workings is over $40,000 in silver ore. On the Desert Queen claim, there is a crosscut tunnel to the vein with drift east on vein for 800 feet. Total underground development is 6000 feet. Orebodies developed have a width of 5 feet to 18 feet; 30 feet to 50 feet in length.

From June 1937 to May 1938, the property was under lease to Sam Mosher and J. D. Williams, of the Imperial Smelting & Refining Company. During this period 2000 tons of ore was shipped to the Garfield smelter of the American Smelting & Refining Company, Salt Lake, Utah. The average grade of ore shipped was 16.69 ounces in silver per ton, with low values in lead and copper. Idle.

Bibl.: State Mineralogist's Reports XI, pp. 349-354; XII, p. 376; XIII, p. 607; XVII, pp. 362-363; XXVII, pp. 347-348; XXXVI, pp. 244-245.

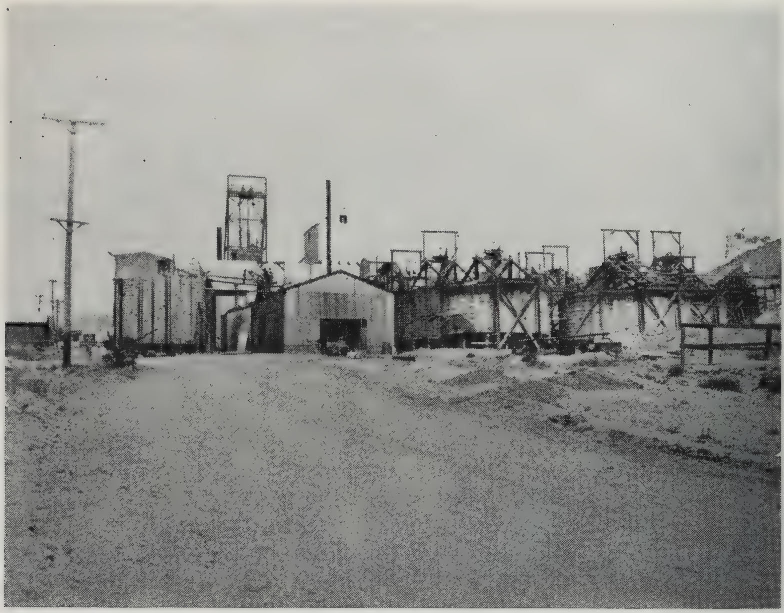

FIG. 11. 200-ton cyanide plant, Kelly Gold and Silver Mines, Red Mountain.

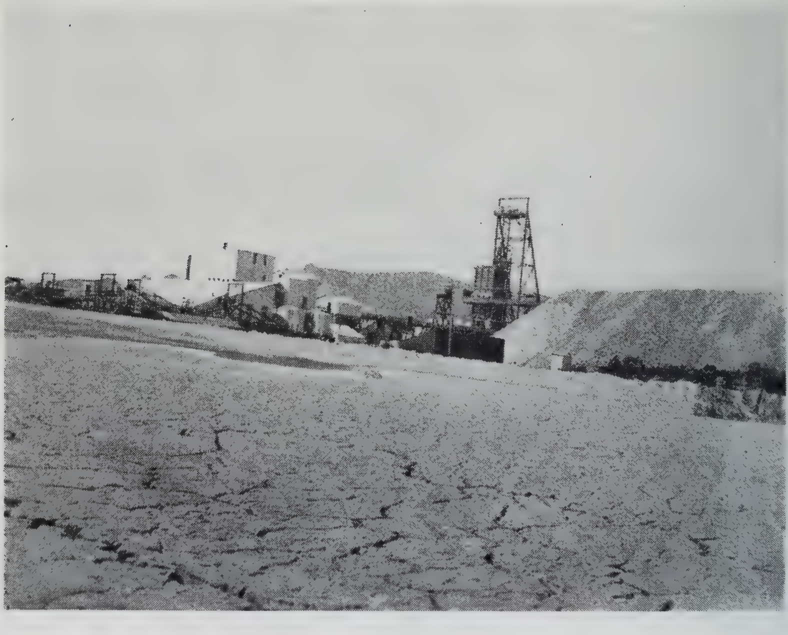

FIG. 12. Head-frame and mill, Kelly Gold and Silver Mines.

Iron Horse mine (formerly *Jack Rabbit*) (lead-silver) comprising 2 claims, is in the Clark Mountain mining district, in sec. 35, T. 16 N., R. 13 E., 18 miles north of Cima and 5 miles south of Wheaton Springs; elevation 5000 feet; owner, Tony Marteletti, Las Vegas, Nevada; under lease and bond to Malcolm L. Huckleberry, c/o Basic Magnesium Company, Las Vegas, Nevada, and Foster Dawson, 819 North Eleventh Street, Las Vegas, Nevada.

The country rock is limestone into which has been intruded a granitic dike. The vein occurs in a fissure in the limestone a short distance from the dike. The strike is N. 20° W., dip 50° to 70° SW. It is traceable on the surface for about 700 feet. Mineralization consists of lead carbonates with occasional spots of galena. These lead minerals carry some silver.

The property has been developed by an inclined shaft on the vein 190 feet, with levels at 60, 100, 150, and 190 feet. Only some 15 to 25 feet of drifting has been done on any of these except the 190-foot level where there is a drift north 45 feet, and on the 150-foot level, where there is a drift north 35 feet. It has been stoped north of the shaft from the 190-foot level to about 25 feet above the 150-foot level for a length of about 30 feet. Five carloads of ore were shipped from these workings between 1927 and 1941. These cars averaged 2.7 ounces of silver, 16 percent lead and about 2.0 percent zinc. The last car which came from the bottom of the shaft contained 23.0 percent lead, 2.20 ounces silver and 2.4 percent zinc.

The present lessees have obtained a development loan from the Reconstruction Finance Corporation and expect to begin sinking the shaft and extracting ore from existing levels in March 1943.

Kelly Gold & Silver Mines (California Rand Silver Mines). The property comprises some 70 claims, of which the original 12 claims are patented, situated in sec. 6, T. 30 S., R. 41 E., M. D., in the Randsburg silver district, 1½ miles southeast of Randsburg; elevation 3695 feet; owner, Kelly Gold & Silver Mines, Homer Gibson, president; Frank Royer, manager, Red Mountain, California.

The property was operated from January 1920 until September 1929 by the California Rand Silver Company; purchased by the Consolidated Metals Company of San Francisco, in September 1929 and operated until July 1930. The property was acquired by the Red Mountain Mines Syndicate in July 1930 and operated until 1933. From 1933 to December 1942, it was operated by Kelly Gold & Silver Mines, Inc., Frank Royer, manager. Since 1931 [10] the property of the Kelly Gold & Silver Mines, Inc. has been operated under a lease system and high-grade silver ore has been shipped to the Selby Smelting Company, Selby, California. The company also constructed and operated a 100-ton cyanide plant as a custom plant to treat gold ores. This plant was operated until the order by the War Production Board suspending gold mining in the latter part of 1942.

Kelly Gold & Siilver Mines production from August 3, 1933 to September 26, 1934 amounted to $394,124.00; from March 1934 to May 1937, to $329,319.00; total production, $723,443.00. The total production of gold and silver from the property to date has been over $16,000,000. Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 361-362; XIX, pp. 61, 98, 99, 167; XX, pp. 48, 49, 96; XXVI, pp. 272, 273, 274; XXVII, pp. 345-346; Bull. 95, pp. 110-121.

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[10] Tucker, W. B., and Sampson, R. J., op. cit.

Kieper Lead-Silver Mine (Bank Roll and Green Gold Groups). This mine comprising 6 claims now known as Glory Hole, Eerie, Eagle's Nest, Yellow Crocus, Diamond Back, and Little Gremlin, is on the west slope of Clark Mountain, 7 miles northeast of Valley Wells and 23 miles north of Cima, a station on the Union Pacific Railroad, in T. 17 N., R. 13 E., S. B.; elevation 6000 feet; owner, G. B. Conklin, Valley Wells, via Nipton, California.

On the three northwesterly claims, the Glory Hole, Little Gremlin, and Yellow Crocus, the country rock is all monzonite, while on the other three there is a contact of this rock with a large body of limestone. On the Glory Hole claim a tunnel has been driven S. 60° E. 285 feet on a fracture in the monzonite. Short lenses of quartz from 6 inches to 2 feet wide form in this fracture. The valuable minerals in this quartz are galena, sphalerite, and chalcopyrite, carrying gold and silver.

At 150 feet from the portal of this tunnel, a winze has been sunk on the vein which dips about 70° NW. A few feet beyond the winze there is a 30-foot drift on a cross fracture S. 30° W. At the face of tunnel, a drift has been driven S. 30° W. 150 feet on another cross fracture. These cross fractures dip about 50° SE. About 100 feet above and 300 feet southeast of portal of this tunnel is a small glory hole under which has been driven a tunnel N. 60° E. 40 feet. Near the south end of the Diamond Back claim, some 1500 feet northeast of the Glory Hole workings, the contact of the monzonite and limestone strikes N. 45° E., dips about 30° SE. Here a tunnel has been driven northeast 30 feet. At the portal there is 6 inches of ore; at 20 feet it widens to about 5½ feet. This is good-looking ore, being a mixture of galena and lead carbonate. Some 25 feet south of this tunnel is a shaft sunk 40 feet on 20° inclination. The possibility of developing ore along this contact is favorable.

Idle except for assessment work.

Bibl.: State Mineralogist's Reports XX, pp. 92-93; XXVII, p. 341.

Lead Mountain Mine. It comprises 640 acres of patented land, in sec. 36, T. 10 N., R. 1 W., S. B., in the Grapevine mining district, 5 miles northwest of Yermo; owner, Pacific Base Metals Company, 727 Subway Terminal Building, Los Angeles; A. Arthur Cohen, president; Miss S. E. Graner, secretary.

The country rock is tuff, andesite porphyry. The ore-bearing fissure strikes northwest and dips 40° NE. Width of mineralized zone is about 100 feet, the orebodies occurring irregularly throughout this area along the strike of the fissure. The vein material is a coarsely crystallized barite, with quartz containing iron oxides, galena, lead carbonate, manganese oxide, and silver chlorides.

Developments: The principal workings are on the south slope of Lead Mountain. They consist of a series of open cuts and tunnels along the strike of the mineralized zone for a distance of 500 feet. A crosscut tunnel driven northeast 75 feet crosscuts the mineralized zone. From this crosscut tunnel, a shaft is sunk on the fissure on an inclination of 33° to a depth of 210 feet. On the north side of Lead Mountain, a crosscut tunnel 1300 feet in length was driven by the Waterloo Mining Company of Calico in 1881 to 1896. There is a 240-foot vertical raise from this tunnel level connecting with stope at bottom of incline shaft from upper workings. Deposit was worked by Pacific Minerals Company during 1931-1933 for its barite.

Bibl.: State Mineralogist's Reports XX, pp. 199-200; XXVII, pp. 349-350; XXVI, p. 245.

Mitchell Mine (lead-silver). It comprises 8 claims situated on the east slope of the Providence Mountains, near Mitchell's Limestone Caverns, in Trojan mining district, in sec. 21, T. 10 N., R. 14 E., S. B., 28 miles northwest of Essex, a station on the Santa Fe Railroad; elevation 4400 feet; owner, J. E. Mitchell, Essex, California.

The country rock is limestone. The Bird Springs formation comprising thin- to thick-bedded gray limestone forms a long ridge to the north and extends in a narrow band along the slopes to Foshay Pass. It is in this formation that the Mitchell caves occur. The Bird Springs formation is highly fossiliferous. On the west side of the limestone belt is a ridge of dacite of Tertiary age. About half a mile north of caves, the limestone is mineralized with lead carbonate and galena, along fissures in the limestone. The mineralization extends over a width of 50 feet and length of several hundred feet. The strike of mineralized fissures in the limestone is N. 30° W., dip 70° E. and where exposed by surface open cuts, are 2 feet to 6 feet in width.

Development consists of a number of shallow open cuts made along fissure for a distance of 100 feet. At a lower elevation, a crosscut tunnel has been driven 50 feet east. About 500 feet would have to be driven to cut mineralized fissure. Samples taken from open cuts are reported to carry 10 to 25 percent lead and 12 ounces in silver per ton. Idle.

Mohawk Mine. It comprises 8 claims situated in the Clark mining district, on Mohawk Hill, on the south slope of Clark Mountain, in sec. 18, T. 16 N., R. 13 E., S. B., 24 miles north of Cima, a station on the Santa Fe Railroad; elevation 4500 feet; owner, Ivanpah Copper Company, L. D. Godshall, vice president and manager, Los Angeles; under lease and option to S. D. Greenwood, Clinton Ray, and Claire Dunton, Los Angeles.

There is a series of parallel fissures in the limestone, mineralized with lead carbonate and zinc carbonate, carrying silver. These fissures strike N. 40° W. and cut across the limestone beds; at the intersection with east-trending fissures having a vertical dip, orebodies of lead-zinc carbonate occur.

On the Wilshire claim, located on the northwest slope of Mohawk Hill, an incline shaft has been sunk to a depth of 200 feet on ore. The fissure strikes S. 40° E. and at the intersection of east-trending fissure, a large body of ore was developed. The orebody was mined on the 70-foot level and 125-foot level for a length of 200 feet and the average width was about 20 feet; stoped to the surface from the 125-foot level. There are approximately 2000 tons of ore on the dump reported to assay 10 percent lead, 3 to 5 percent zinc, and 5 ounces of silver per ton. About 500 feet east of these workings, a diorite dike cuts across the limestone beds, strike N. 40° W., dip vertical; 8 to 10 feet wide. On the west side of the dike, a shaft was sunk to a depth of 30 feet exposing 6 feet of ore. Samples taken across 6 feet are reported to assay 18 percent zinc. On the south slope of Mohawk Hill, the limestone overlies the granite which forms the core of the mountains. Two parallel ore fissures have been developed by tunnels, driven at different elevations. The easterly vein strikes N. 40° W., dip 46° SW.; 4 feet to 6 feet wide. A crosscut tunnel has been driven N. 30° E. in granite 175 feet to fissure, then raise 25 feet high, with drift along fissure in limestone for a distance of 175 feet. Two parallel fissures were developed with 8 feet to 15 feet of limestone between these vertical fissures. The ore mined was lead carbonate reported to carry 16 to 30 percent lead. This orebody was stoped to the surface and the production in 1917 amounted to $70,000.00. Lead-zinc carbonate ore occurs on the footwall of the lead orebody and was not mined on account of its zinc content. Recent sampling of ore left in stopes on these two fissures is reported to assay 10 percent zinc and 3 percent lead. About 1000 feet west of these workings, a shaft was sunk to a depth of 140 feet on an east-trending fissure in the limestone. A crosscut tunnel driven N. 30° E. 240 feet connects with shaft. The ore developed is lead-zinc carbonate and has been drifted on 200 feet E. The lead ore carrying low zinc values was stoped and shipped. There is considerable lead-zinc carbonate ore left that under present prices may be commercial. The ore on the dumps is reported to assay 10 percent zinc, 3.5 percent lead and 5 ounces in silver per ton. Two men are employed sampling ore in the mine workings.

Bibl.: State Mineralogist's Reports XVII, p. 363; XXVII, p. 353.

Mowry Mine. It comprises 12 claims situated in the Lava Bed mining district, in sec. 35, T. 7 N., R. 5 E., S. B., 9 miles southwest of Lavic, a station on the Santa Fe Railroad; elevation 4000 feet; owner, Mowry Mines Company, D. G. MacGregor, president and manager, Haynes, California.

The vein occurs in quartz porphyry, strike northwest, dip 70° NE. Width varies from 7 to 30 feet and consists of a mass of crushed and broken country rock along a fault fracture. The ore is copper oxides, cerussite, and galena, carrying gold and silver. Development consists of four shafts from 85 to 250 feet in depth sunk on the vein; also, two tunnels 105 feet and 310 feet in length, the total amount of development work being 2500 feet. Idle.

Bibl.: State Mineralogist's Reports XI, pp. 358-359; XXVII, pp. 353-354; XXXVI, pp. 245-256.

Nigger Mountain Mine (Mohawk Group). It comprises 10 claims situated in the Black Hawk mining district, on the east slope of the San Bernardino Mountains, east of Burnt Flat, in the NE½ SW¼ sec. 23 and the SE¼ sec. 22 and the NE¼ sec. 27, T. 3 N., R. 1 E., S. B., 10 miles southeast of Lucerne Valley P. O. and 33 miles southeast of Victorville; elevation 6500 to 6800 feet; owner, J. L. Tomlinson, Big Bear Lake, San Bernardino County, California; under lease and option to Universal Industries, Inc., W. Scott Hall, president and manager; M. L. Meyer, secretary; Alex McLaren, superintendent, 5160 Linwood Drive, Los Angeles.

The formation is limestone and granite. The vein strikes S. 60° W., dips 65° NW. and occurs on the contact between limestone and granite. The vein has a width of 6 to 8 feet. The ore is galena, cerussite, sphalerite, with gold and silver.

The development consists of two tunnels. The upper tunnel is driven southwest 180 feet. The ore exposed in this tunnel is 6 to 8 feet in width and samples taken are reported to carry 18 to 20 percent zinc, 2 percent lead and 30 percent iron. The lower tunnel is 300 feet in elevation below upper tunnel and is driven as a crosscut N. 35° W. 133 feet to contact of limestone and granite, then a drift southwest on contact 170 feet. The ore shoot developed in lower tunnel has an average width of 8 feet and is 70 feet in length. The ore is lead carbonate with some zinc sulphide. The average grade of ore shipped from these workings to the U. S. Smelting, Refining & Mining Company, Midvale, Utah, assayed 22 percent lead, 7 percent zinc and 20 ounces in silver per ton. Present development consists of drifting on sulphide ore in face of drift and sinking a winze on lead carbonate ore. The winze is sunk on an inclination of 20° to a depth of 40 feet and raise up 25 feet, at 70 feet southwest of crosscut tunnel. At 110 feet southwest of crosscut tunnel cut zinc sulphide ore which has been developed for a length of 60 feet. Width of ore is 5 feet; reported to average 11 percent zinc.

The property is equipped with Ingersoll-Rand portable compressor, air drills, trucks and bulldozer. Ten men are employed on development work.

Santa Fe Mine (Wortley Consolidated Mines Co.). The property comprises 15 claims in the Randsburg silver district and is in the town of Red Mountain, adjoining Kelly Gold & Silver Mines' property on the northeast, in sec. 6, T. 30 S., R. 41 E., M. D., 1½ miles southeast of Randsburg, Kern County; elevation 3690 feet; owner, Wortley Consolidated Mines Company, C. C. Wortley, president, San Fernando, California.

From 1935 until 1938, the property was under lease and option to the Gold Bend Mining & Milling Company, F. E. Miller, president; F. H. Lamley, manager, Red Mountain P. O., California. During the above-mentioned period ore was shipped to the Magma Copper Company, Superior, Arizona.

The northeast-trending and north-trending fissures of the Randsburg silver district traverse the Rand schist on this property. These veins are similar to the veins of the Kelly Gold & Silver Mine in that the schist is mineralized along the two systems of fracturing. The vein filling consists of silicified schist, quartz and brecciated schist, recemented with quartz. The mineralization consists of antimonial sulphides of silver, associated with pyrite, chalcopyrite, and stibnite. Width of veins ranges from about 2 to 80 feet. Development consists of a vertical shaft 1200 feet deep, with levels driven at the 935-, 1000-, 1100-, and 1200-foot horizons. Total underground development from this shaft is 8000 feet. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 360-361.

Silver Bell Mine. It comprises 8 claims situated in the Lava Bed mining district, in the Lavic Mountains, in sec. 12, T. 7 N., R. 4 E., S. B., 17 miles southeast of Newberry, a station on the Santa Fe Railroad; elevation 3000 feet; owner, Rare Metals Corporation, Mrs. O. J. Bellamy, president, Inglewood, California.

Vein system consists of a series of roughly parallel fault fractures in rhyolite. Development consists of crosscut tunnel driven south 1050 feet. Mine equipment consists of 50-horsepower diesel engine, direct connected to 30 K. W. generator; single drum, electric hoist; small plant installed on property for recovery of rare metals.

Bibl.: State Mineralogist's Reports XXVII, pp. 355-356; XXXVI, p. 246.

Silver Cliff Mine. It comprises 19 claims situated in the Lava Bed mining district, in Lavic Mountains, in sec. 18, T. 7 N., R. 5 E., S. B., 18 miles southeast of Newberry, a station on the Santa Fe Railroad; elevation 4000 feet; owner, Silver Cliff Mining Company, Frank A. Humphrey, president, Los Angeles.

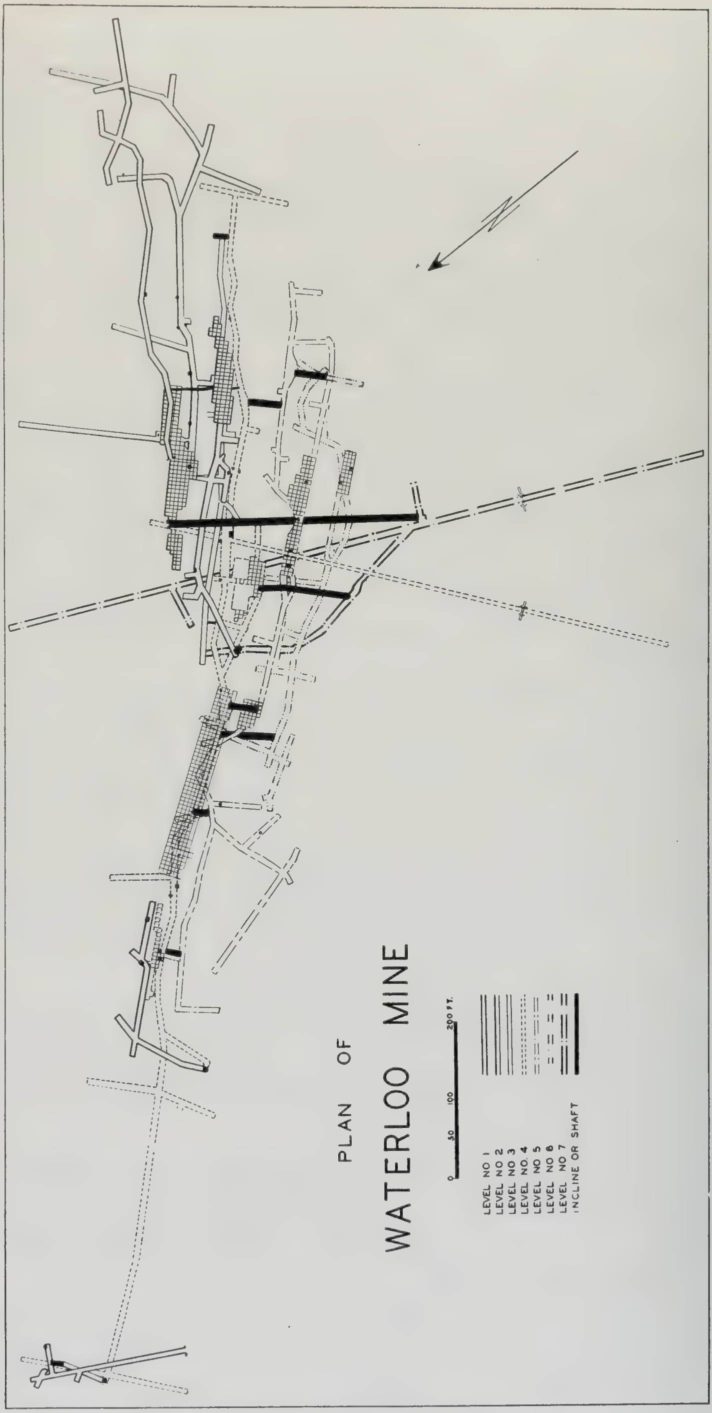
PLAN OF
WATERLOO MINE
0
50
100
200 FT.
LEVEL NO 1
LEVEL NO 2
LEVEL NO 3
LEVEL NO. 4
LEVEL NO 5
LEVEL NO 6
LEVEL NO 7
INCLINE OR SHAFT
N

FIG. 13. Plan of Waterloo mine.

Ore carrying lead and silver occurs along northwest- and north-trending fissures in limestone. Development consists of vertical shaft 376 feet deep and a shaft sunk on an inclination of 75° to a depth of 150 feet. These shafts are connected on the 150-foot level. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 356-357.

Silver Rule mine, comprising 5 claims, is in the Resting Springs district in the Kingston Mountains, 17 miles east of Tecopa, in T. 19 N., R. 11 E., S. B.; elevation 4800 feet; owner, John Prado, Fontana, California.

The ore occurs as irregular lenses of lead carbonate and galena along a fracture in the limestone. Lenses apparently form at the intersection of cross fractures. Main strikes are northwest, dips 70° N., cross fractures about N. 20° W., dip 70° SW. The orebody ranges from 3 feet to 15 feet in width and is said to carry from 20 to 40 percent lead, 10 to 20 ounces silver and 7 to 10 percent zinc. Ore shoot developed is practically 100 feet long and has been partially stoped in the two upper tunnels.

Development consists of four tunnels. The upper tunnel (No. 1) is 220 feet in length; 75 feet below No. 2 tunnel is 400 feet long. A raise in ore connects these two. Five hundred and sixty feet below No. 2, a crosscut was driven southwest 200 feet and a drift 200 feet west on a fracture in the limestone. At an elevation of 3410 feet, a tunnel in the limestone has been driven south 300 feet. Idle.

Bibl.: State Mineralogist's Reports XV, p. 104; XVII, pp. 365-366; XXII, p. 500; XXVII, p. 357.

Union Mine. It comprises 6 claims adjoining the Waterloo mine on the north, in the Calico mining district, in sec. 16, T. 10 N., R. 1 E., S. B., 4 miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 2300 feet; owner, Union Mining Company, Jack Moore, president and manager, Yermo, California.

The vein consists of a shear zone along the contact of rhyolite breccia and the sedimentary lake bed series. The vein trends N. 50° W., dip 50° SW., width 6 to 30 feet. The ore occurs as iron-stained brecciated wall rock, carrying gold, silver, and lead carbonate.

Development consists of a crosscut tunnel driven northeast 400 feet to the vein, with a winze sunk on the vein to a depth of 100 feet. Equipment consists of compressor, air drills, and tugger hoist. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 246.

War Eagle Mine. It comprises 9 claims situated in the Bullion Mountains, in secs. 2 and 3, T. 4 N., R. 10 E., S. B., 9 miles south of Bagdad, a station on the Santa Fe Railroad; elevation 1500 feet; owner, L. W. Osborne, Los Angeles; under lease to J. L. Carder, Los Angeles.

The ore deposits occur in a well-defined fault fracture in rhyolite porphyry, striking N. 60° W. and dipping 40° SW. The hanging wall of the fault is a brecciated tuff. The ores found along the fault fissure are chlorides, chloro-bromides of silver, galena, lead carbonate, wulfenite (molybdate of lead), and vanadinite (vanadate of lead).

Development consists of an incline shaft 700 feet in depth, and 7000 feet of drifts and crosscuts. Idle.

Bibl.: State Mineralogist's Reports XVII, p. 336; XX, pp. 95-96; XXVII, p. 359; XXX, p. 325.

Waterloo Mine. The property comprises 8 patented claims situated in the Calico mining district, in sec. 16, T. 10 N., R. 1 E., S. B., on the west slope of the Calico Mountains, 4 miles northwest of Yermo; elevation 1900 feet to 2200 feet; owner, Waterloo Mining Company, J. T. Weakely, president; P. H. Krick, secretary, Anaheim, California.

The orebodies occur along the Waterloo fault zone which strikes N. 50° W. and dips 40° SW. The Waterloo vein occurs on contact of sedimentary rocks and tuff-breccia. The tuff-breccia is the footwall of the orebodies. The orebodies mined were large, irregular masses and bunches that extended along the fault zone for a distance of 1100 feet. The stopes ranged up to 200 feet in length, with widths of 20 feet to 80 feet. A large tonnage of ore was mined and treated in the Waterloo Mining Company's mill near Daggett from 1881 to 1896. The ore milled is reported to have carried from 11 to 20 ounces in silver per ton, there being a loss of 5 ounces in the tailings. The ore is chlorides and chloro-bromides of silver in a gangue of barite and jasper. The silver minerals are cerargyrite, embolite, and a little chrysocolla.

Development: The lower tunnel was driven N. 30° E., 2300 feet and at 1750 feet from the portal intersected the main shaft which was sunk on the vein to a depth of 350 feet, on an inclination of 50°. The tunnel is entirely in the sedimentary rocks with inclusions of tuff members of the upper lake bed series. At 290 feet in elevation above lower tunnel, the upper tunnel is driven as a crosscut N. 50° E., 600 feet to the Waterloo vein and connecting with shaft on the fourth level.

From the incline shaft 5 levels have been driven on the vein at intervals of approximately 50 feet. At the elevation of collar of the shaft, first level is driven southeast of shaft from big stope from second level. The following is the amount of drifting on the different levels:

1st level	550 ft.
2nd level	700 ft.
3rd level	550 ft.
4th level	1500 ft.
5th level	900 ft.
6th level	500 ft.

Seventh level or Main crosscut tunnel level 2300 feet, with 300 feet of crosscuts. On fourth level, there are 800 feet of crosscuts. The total amount of underground development is approximately 10,000 feet. Incline shaft and main tunnel level are in good condition and most of the levels are accessible.

There is a limited tonnage of ore exposed from third level to first level, southeast of shaft; also ore exposed on sixth level, northwest of shaft for a disance of several hundred feet which has not been stoped. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 498; XI, p. 343; XII, p. 376; XIII, p. 609; XXVII, pp. 359-360.

Wonder Mountain Mines, Inc., L. G. Blakemore, president and general manager, has 4 claims in the Clark Mountain district, in sec. 15, T. 17 N., R. 14 E., S. B., near state line, 22 miles from Jean, Nevada, which is the shipping point.

The country rock consists of dolomitic limestone which has been intruded by quartz monzonite. The orebodies are replacements of the altered limestone along fractures near the monzonite. The Wonder vein, crossing the bedding planes of the limestone, is 6 feet wide and is practically vertical. The valuable metallic minerals are lead, silver, and gold.

Development consists of 35-foot tunnel, several shallow shafts and open cuts. The company is planning to sink a shaft on the Wonder vein. Idle at present.

Yucca Metals Mine. It comprises 17 claims, situated in the Clark mining district, on the south slope of Mohawk Hill and adjoins the Mohawk mine on the northeast, in sec. 17, T. 16 N., R. 13 E., S. B., a quarter of a mile northwest of Clark Mountain Station on U. S. 91 Highway and 24 miles north of Cima, a station on the Union Pacific Railroad; elevation 4500 feet; owners, Yucca Metals Mining Company, C. W. Brown, president; Walter H. Voyles, secretary; C. A. Housel, superintendent, Clark Mountain Station, via Nipton, California.

Ore occurs on contact of blue limestone and white limestone which strikes eastward and at intersections of east-trending and N. 40° W. fissures in the limestone. Development consists of two shafts on the northeast slope of Mohawk Hill, sunk to depth of 50 feet. Ore is lead carbonate with values in silver. Two cars of ore shipped in 1917 carried 19 to 24 percent lead, and 5 ounces in silver. On the south slope of Mohawk Hill are a number of shafts and open cuts on the contact of blue limestone and white marbleized limestone which developed small bunches of lead carbonate ore. At lower elevation two tunnels have been driven northwest to cut the contact.

Annex tunnel No. 6 is driven northeast 500 feet; at 410 feet from portal drift northeast 200 feet in dioritic porphyry carrying low values in copper; then drift north 200 feet in blue limestone. Northeast of these workings is the Blacksmith tunnel driven N. 30° E. in flat beds of blue limestone, 100 feet to fault, with drift along fault N. 30° W., 100 feet. Small, irregular bunches of lead ore were found along the fault.

Equipment consists of blacksmith shop, air drills, cars and track. Idle.

Zenda Gold Mining Company (Oriental-Silver King mines), W. F. Staunton, president; T. R. Drummond, secretary and manager, 1253 Pacific Mutual Building, Los Angeles; under lease to John Coke, Calico, California. This company owns the Oriental and Silver King group of mines, comprising 35 patented claims, situated in secs. 15 and 22, T. 10 N., R. 1 E., S. B., in the Calico mining district, 3½ miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 2500 to 2600 feet.

There are two systems of veins on the property known as the Oriental and Silver King fissures which occur in rhyolite tuff, along what is known as the King system of fault fractures. The Oriental vein intersects the Silver King vein near the southwest corner of the Silver King claim. The vein system strikes northwest and dips 70° southwest. Towards the southern end of the vein system considerable faulting has followed the fracturing, while at the northern end of the system, the deposits occur as typical fissure veins with well developed walls. Along this system of fault fractures the crushing of the rock and faulting reached its maximum on the Red Cloud and Red Jacket claims. Here, the rhyolite tuff in places is completely disintegrated and brecciated; and barite and jaspery silica encloses more or less uniformly distributed chlorides and chloro-bromides of silver. Cerargyrite and embolite mostly occur as thin coatings in joints and cracks but also often imbedded in the barite. The ore shoots are irregular and occur along the fault fissures, forming orebodies 20 feet to 50 feet in thickness. The ore mined is reported to carry 10 to 40 ounces in silver. In lower levels, some irregular lenses were encountered mineralized with chalcopyrite, tetrahedrite, and pyrite.

Development: The Silver King and Oriental veins are developed by two shafts. No. 1 shaft is a vertical shaft 340 feet in depth and 542 feet southeast of No. 2 shaft is a 3-compartment, vertical shaft 550 feet deep, with drifts and crosscuts on the 320, 430 and 530-foot levels. The total amount of development from No. 2 shaft consists of 15,000 feet of crosscuts and drifts on the above-mentioned levels. On the 530-foot level crosscuts have been driven northeast to the Silver King vein. A drift on the 320-foot level connects with the workings from No. 1 shaft.

All equipment has been removed from the property and sold. Idle.

Bibl.: State Mineralogist's Reports VIII, pp. 491-498; IX, p. 224; X, p. 530; XI, pp. 337-344; XII, p. 376; XIII, pp. 606-607; XVII, pp. 359-366; XXVII, pp. 362-364; XXXVI, pp. 247-248; Trans. Am. Inst. of Mining & Metallurgical Engrs. Vol. XV, p. 718.

Manganese

Deposits of manganese ore occur in the desert regions of San Bernardino County, in the Lavic Mountains, Owl Mountains, Whipple Mountains, and along the Colorado River near Parker. With the active participation of the United States in the war, the need for strategic and critical minerals in the war production industries has become greater. Manganese ore is one of the important strategic metals. The Metals Reserve Company, Washington, D. C., effective May 4, 1942, will purchase domestic manganese ores on the following price schedule: All prices per long ton (2240 pounds) dry weight, f.o.b. cars at stock pile designated by the Metals Reserve Company.

High Grade: Base price $48.00 per long ton for ore containing 48 percent manganese.

Low Grade A: Base price $35.20 per long ton 44 percent manganese.

Low Grade B: Base price $26.00 per ton for ore containing 40 percent manganese. Ore containing a minimum of 35 percent manganese will be accepted under this schedule with a penalty of $1.30 per ton for each unit less than 40 percent.

Stockpile points for receiving ores from southern California producers have been established by Metals Reserve Company and are at Parker and Phoenix, Arizona.

Kaiser Company, Inc., Fontana, California, is in the market for the purchase of low-grade ores ranging from 15 to 35 percent.

These price schedules and increased demand for domestic manganese ores have resulted in the reopening and development of manganese deposits throughout the county.

Manganese ore was shipped from five deposits in San Bernardino County during 1942. The material varies in grade from 20 to 46 percent manganese. The 35 percent Mn grade and up is shipped to Metals Reserve Company's stockpile at Parker and Phoenix, Arizona; the low grade, 20 to 35 percent Mn, to steel plant at Fontana, California.

Black Butte Mine (Matt & Pisgah). It comprises 6 claims situated on the southwest slope of Cady Mountains, in sec. 10, T. 8 N., R. 6 E., S. B., 2 miles north of Pisgah Siding on the Santa Fe Railroad, and 21 miles east of Newberry; elevation 2400 feet; owner, C. S. Van Doran, Daggett, California.

Manganese occurs along a fault in dacite which strikes north and dips 70° W. The ore is pyrolusite and psilomelane, intermixed with crushed wall rock. The width of ore along the fault is from 4 to 6 feet. Two tunnels have been driven north along fault fracture a distance of 60 feet. The upper tunnel is 20 feet above lower tunnel. One hundred tons of ore was shipped from this deposit in 1918 reported to carry 40 percent manganese. In 1942 the property was under lease to Arthur Dunaetz, Los Angeles. Shipped 100 tons 19 percent manganese, mined from open cut on desert plain a quarter of a mile south of workings on hill, exposing outcrop of manganese oxides mixed with andesitic fragments. The open cut exposed 25 feet of ore 100 feet in length and mined to a depth of 15 feet. Strike of orebody is north, dip vertical.

Equipment consists of 300-cubic foot compressor and ¾-cubic yard shovel. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 241.

Black Magic Mine (Emma). It comprises 13 claims situated on the south slope of Owls Head Mountains, in sec. 10, T. 18 N., R. 3 E., S. B., 35 miles northwest of Riggs, a station on the Tonopah & Tidewater Railroad, and 55 miles by road north of Dunn Siding on the Union Pacific Railroad; elevation 2800 feet; owners, Jack Hilliard, Beatty, Nevada, and Roy Watkins, Baker, California; under lease to Harry Nasland, Beverly Hills, California.

There are many outcrops of manganese ore on the claims. They occur at the contact of limestone and granite and also in the limestone. The strike varies from N. 20° W. on the contact to east in the limestone. Some of these deposits are from 4 to 5 feet wide, with about the same depth and from 20 to 50 feet long, deposited in ''V'' grooves in the rock, at the surface. In the limestone an east-trending vein dips 25° N. It is from 2 feet to 8 feet wide. The ore, which is largely psilomelane, would require considerable sorting to bring it to commercial grade. Numerous open cuts have been made on the various outcrops. These have resulted in considerable tonnage of ore in the aggregate on the dumps. After much difficulty resulting from damage to the road to the mine by cloudburst, the lessee has discontinued his operation.

Bibl.: State Mineralogist's Reports XVII, p. 354; XXVII, p. 337; Bull. 76, p. 62.

Black Mountain manganese mines comprise a group of claims known as Black Mountain copper mine group situated on the southern slope of Dead Mountain, in Ibex mining district, in sec. 30(?), T. 10 N., R. 22 E., S. B., 4 miles north of Java, a station on the Santa Fe Railroad and 10 miles northwest of Needles, California; elevation 1000 to 1500 feet; owner, Black Mountain Mining Company, Needles, California.

The manganese ore occurs in small, scattered lens-shaped bodies in gneiss. The bunches of ore are less than 10 feet in length, and range from 6 inches to 3 feet in width. The ore is psilomelane, through which is intermixed considerable calcite. Developed by trenches and open cuts. The ore is reported to carry manganese 35 to 40 percent, silica 5 to 15 percent, iron 5 to 15 percent, lime 15 to 25 percent.

Black Tiger manganese deposit, comprising 2 claims, is on the southwest shore of Lake Havasu, 30 miles above Parker and 15 miles up the lake from the Parker Dam, in sec. 32, T. 4 N., R. 26 E., S. B.; owner, A. R. Orchard, 215 East Palmer Avenue, Glendale, California.

The deposit occurs in a basaltic breccia which has been rather loosely recemented. It strikes N. 40° W., dip about 45° SW.; width, as exposed, up to 50 feet. It forms the east side of a ridge. This whole mass for a length of several hundred feet is heavily stained with manganese oxides and narrow streaks of a few inches to 3 or 4 feet look to be higher grade. It is reported that trenching has indicated possibly 400,000 tons of 12 to 15 percent manganese. Idle.

Cactus Central Manganese Mine. It comprises 6 claims situated in the Monumental mining district in the Whipple Mountains, adjoining the Manganese King group of claims, 2½ miles west of Monument Peak, in sec. 6, T. 2 N., R. 26 E., S. B., 6 miles north of Cross Roads and 10 miles north of Parker, Arizona; elevation 2000 feet; owner, W. H. Miller, Pasadena, California.

Veins of manganese oxides occur in jasper and tuffaceous limestone. The ore is psilomelane and pyrolusite. The veins are from 12 inches to 2 feet wide. The ore is reported to carry from 30 to 45 percent manganese. Idle.

Juleff Manganese Mine. It comprises 4 claims known as Willette group situated in Monumental mining district in the Whipple Mountains, 6 miles north of Cross Roads and 10 miles north of Parker, Arizona, in T. 2 N., R. 26 E., S. B.; owner C. E. Moulton, Cross Roads; under lease to James Juleff, Parker, Arizona; elevation 2200 feet.

These claims adjoin Manganese King manganese property on the southeast. Irregular masses of manganese oxide ore occur in a bright red hematite matrix, on contact of tuffaceous limestone and andesite breccia. The general strike of vein is north, dip 50° W.; width 2 feet. Development consists of open cut 20 feet in length by 6 feet in depth. From the deposit to road to Manganese King mines there is an aerial tram 1000 feet in length.

About 10 tons of ore has been mined and shipped to Metals Reserve Company's stock pile at Parker, Arizona. Ore is said to run 48 percent manganese, 6 percent SiO_2. Two men are employed.

Lavic Mountain Manganese Mine (Garinger Mine). It comprises 10 claims situated on the southeast slope of the Cady Mountains, in secs. 22 and 23, T. 8 N., R. 7 E., S. B., 7 miles northwest of Ludlow and 3½ miles north of Argos, a station on the Santa Fe Railroad; elevation 2900 feet; owners, Lee W. Yim and Mrs. A. N. Rabe, Ludlow, California.

In 1917, the property was owned by I. D. Garinger, Daggett, California, and L. G. Root, Needles, California. In October 1917, 100 tons of selected ore was shipped to Lewellyn Iron Works, Torrance, California. Analysis: Manganese 35 percent, silica 12 percent, iron 0.5 percent.

Three manganese ore outcrops occur on the claims on top of a ridge in a belt some 200 feet in width and about 1500 feet in length. The main or west outcrop strikes east, dip 75° N.; width 2 feet to 15 feet. The manganese oxides occur against a hard, red rhyolite agglomerate along the southwest slope of the ridge. The ore is psilomelane, with a gangue of silica, calcite, and unaltered fragments of rhyolite. Average sample of ore along the outcrops is reported to carry 22 percent manganese, 1.2 percent iron, 18 percent silica. The probable tonnage of ore carrying 25 percent manganese is estimated at 10,000 tons. Development consists of a shaft 40 feet deep sunk along main outcrop and about 1800 feet east of this shaft are two open cuts 8 feet deep and 20 feet in length. Width of ore exposed is 4 feet to 6 feet; reported to assay 30 percent manganese.

From surface cuts east and west of the shaft, there is an indicated ore shoot 30 feet in length and 6 feet in width, reported to assay 20 percent manganese. Idle.

Bibl.: Bull. 76, p. 62; State Mineralogist's Reports XVII, pp. 355-356; XXVII, pp. 337-338.

Logan manganese deposit, consisting of 6 claims, is in sec. 32, T. 9 N., R. 6 E., S.B., about 7 miles northeast of Hector, a station on the Santa Fe Railroad; owner, -- Logan, Daggett, California; was under lease to Suckow Borax Mines Consolidated, 40 St. James Park, Los Angeles.

The deposit occurs in a brecciated basalt at its contact with the monzonite country rock. The ore mineral, psilomelane, is deposited in stringers and nodules in the breccia, with here and there larger but discontinuous streaks up to 2 feet or more in width. The strike of the deposit is N. 65°-70° W., the dip approximately 70° N. It has been opened for a length of about 230 feet. At no one point has it been mined for more than 20 feet below the outcrop. A steep road about three-quarters of a mile in length was built to the deposit.

The deposit was opened by a trench 230 feet long, from 6 feet to 15 feet wide and from 5 feet to 20 feet deep. At one point a northeastward-striking cross-vein about 5 feet wide was worked for a length of 20 feet. From these workings 2000 tons of 19 percent Mn ore were shipped to the Kaiser plant at Fontana and 100 tons of 40 percent Mn were shipped to Government stock pile. Idle.

Manganese King Mine (Hidden Cross). It comprises 12 claims situated in the Whipple Mountains, in the Monumental mining district, in the SE¼ sec. 1, T. 2 N., R. 25 E. and the SW¼ sec. 6, T. 2 N., R. 26 E., S. B., 2½ miles west of Monument Peak, 6 miles north of Cross Roads and 10 miles north of Parker, Arizona; elevation 2000 feet; owner, Fred M. Hall, Los Angeles; under lease to C. E. Moulton and H. H. Clarke, 306 West Third Street, Los Angeles.

The ore zone on these claims is about 10 feet thick, being underlain by jasper and overlain by tuffaceous limestone. An ore zone consisting of irregular masses of manganese oxide ore in a bright red hematite matrix, extends for at least 1½ miles through the NE ¼ sec. 1, T. 2 N., R. 25 E. and the SW¼ sec. 6, T. 2 N., R. 26 E., S. B. There is a parallel zone about 600 feet southwest of the above-mentioned ore zone. The ore is psilomelane and pyrolusite. Development consists of open cuts near the northwest end of the ore zone and shallow shafts.

It is reported that during 1917 to 1918, some 200 tons of ore, carrying 45 percent manganese and less than 10 percent SiO_2 was shipped from the property.

During 1942 a truck road was built up the canyon about half way to loading bins, a distance of one mile; then a tractor road the remaining distance to the mine workings, about another mile. During the early part of 1943, several shipments were made to Metals Reserve Company's stock pile at Phoenix, Arizona. The grade of the ore shipped was reported to be 35 percent manganese.

Equipment consists of portable compressor, caterpillar tractor and ore bins. Idle.

Owl's Hole manganese mine (New Deal) is in sec. 22, T. 18 N., R. 3 E., in the Owl Mountains, northwest of Owl Hole Spring, about 36 miles west of Riggs, a station on the Tonopah & Tidewater Railroad. It is now being worked by the K. S. Mining Company, L. R. Peck, First National Bank, Clearwater, California, and D. A. Kendall, Box 76, Baker, California; owner, Kern Leasing Company, Harold W. Orwig, president; R. L. Gilmore, consulting engineer, Los Angeles.

The manganese oxides occur along a series of fault fractures which strike northwest in granite, and also on contact between limestone and granite.

Since 1931 [11] the open cut on the east side of the gulch near the southeast end of the property has been worked to a depth of from 20 feet to 35 feet, across a width of from 20 feet to 35 feet. The 60-foot shaft is about at the center of this pit. This ore was hoisted and run over picking conveyor belts. This operation was discontinued and the equipment removed. The bottom and ends of this pit show manganese oxides mixed with granitic conglomerate.

Some 1800 feet west of this pit a shaft was sunk 50 feet with 20 feet of drifts each way at the bottom; also an adit drift driven northwest about 75 feet connects with the shaft at 30 feet. Some small bunches of ore were here stoped from 4 feet to 5 feet wide. The ore here strikes about N. 50° W.

Recent operators are shipping to the steel plant of Kaiser Company, Inc., Fontana, California. The ore shipped is reported to average 19 percent manganese. Six men are employed.

Bibl.: State Mineralogist's Reports XVII, p. 355; XXVII, p. 338; Bull. 76, pp. 62-64.

Stewart Manganese Mines. The property comprises 12 claims situated in the Whipple Mountains, in sec. 6, T. 3 N., R. 25 E., S. B., 6 miles southeast of West Well and 42 miles by road southeast of Needles; elevation 1500 feet; owner, J. W. Stewart, Needles, California; under lease to J. E. Vandergrift, 6350 Franklin Avenue, Hollywood, California; he plans to begin shipment of manganese ore to Kaiser Company, Inc., commencing in November 1943.

A series of parallel veins occurs in andesite and andesitic breccia; strike northwest. Dips range from 60° to 70° SW. Widths range from 12 inches to 3 feet. Four veins have been exposed on the property by open cuts, shallow shafts and short tunnels. The ore mined is psilomelane, associated with pyrolusite. Average grade of ore shipped is 30 percent manganese. Some selected ore shipped to stock pile at Parker, Arizona, carried 36 percent manganese.

The principal development work is confined to No. 1 vein which occurs along a fault fracture in andesite. The mineralized zone is 25 feet wide and 75 feet in length. A 3-foot vein of manganese occurs on the footwall. Vein strikes N. 30° W., dip 70° W. There is an open cut on this vein 70 feet in length and 12 feet in width. Twenty feet below open cut, a tunnel has been driven southeast 60 feet. The ore from open cut and tunnel goes to 50-ton ore bin. These workings produced 150 tons of ore reported to carry 31 percent manganese. No. 2 vein has been developed by a short tunnel 20 feet in length. On No. 3 vein, a shaft has been sunk to a depth of 14 feet, with a drift 20 feet in length on the vein. The manganese oxides are mixed with fragments of andesite. Screen tests of this material produced 30 percent manganese in the fines. No. 4 vein has been exposed on the surface by open cut 200 feet in length. Width of ore exposed is 12 inches to 2 feet. Four cars of ore was shipped from this open cut to Metal Reserve Company's stock pile at Parker, Arizona reported to carry 36 percent manganese.

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[11] Tucker, W. B., and Sampson, R. J., op. cit.

Equipment consists of 3 portable compressors, one with a capacity of 365 cubic feet; the others have a capacity of 110 cubic feet; caterpillar tractor; bulldozer and trucks. Ten men are employed.

Molybdenum

The two principal molybdenum minerals are the sulphide, molybdenite (MoS_2) and wulfenite, lead molybdate, the former furnishing practically the entire commercial output. Molybdenite is found associated with acidic igneous rocks, such as granite and pegmatite. Deposits of disseminated molybdenite are known in several localities in San Bernardino County. In the New York Mountains it occurs in small masses associated with copper and tungsten ores. Small, kidney-like deposits of molybdenite also occur in granitic gneiss on the ridge west of south fork of Lytle Creek, 2 miles west of Glen Ranch. The only development and a small production of molybdenite concentrates was from the Big Hunch group of claims situated in the New York Mountains. A small shipment of concentrates was made from the property in 1917-1918.

Big Hunch (Brooke) molybdenite mine (see also *Brooke mine,* page 501) comprises 4 patented claims known as Omega, Beta, Big Hunch, and Big Hunch No. 1, situated in the New York Mountains, in sec. 35, T. 14 N., R. 15 E., S. B., 10 miles east of Cima, a station on the Union Pacific Railroad; elevation 6700 feet; owners, J. F. Brooke and F. M. Brooke, Barstow, California; under lease and option to H. H. Pike, 3330 F Street, San Bernardino, California.

The country rock is granitic. A huge quartz vein (segregation), strike N. 75° W., dip 54° N., traverses the granite for 5 miles. It reaches 50 feet or more in thickness, and in many places the vein rises 35 to 40 feet above the surrounding rock. The footwall of the vein is well defined by a distinct plane along which, where seen, there is a clay gouge from 3 to 6 inches wide. The footwall is a coarse-grained alaskite. The hanging wall is not defined, the quartz gradually merging into a more or less normal granite. Along the footwall of this vein, below the 90-foot level, lenses of molybdenite are said to occur which are separated from the quartz on the hanging wall by a distinct plane. It is said that below the 90-foot level, in the shaft, molybdenite is also disseminated through the quartz mass. In the canyon below the shaft collar an open cut exposes face of ore which is approximately 100 feet below the collar of the shaft. Lenses of ore are exposed at the collar of an old shaft, now full of water, still farther down the canyon.

In 1917-1918 a shaft was sunk on a 52° inclination to a depth of 250 feet. It is filled with water to the 90-foot level where an adit driven west 120 feet connects with the shaft. It is reported that on the 200-foot level, a drift has been driven east 48 feet and west 15 feet on the vein and a crosscut driven north 40 feet exposing 30 feet of quartz. On the 250-foot level, drift 15 feet east and 15 feet west on the vein. Samples cut in these workings are said to have averaged 1.8 percent molybdenite, across widths of 5 to 7 feet, while it is estimated the remainder of the quartz will average one-quarter of 1 percent molybdenite.

The property is being unwatered for the purpose of applying for development loan from the Reconstruction Finance Corporation.

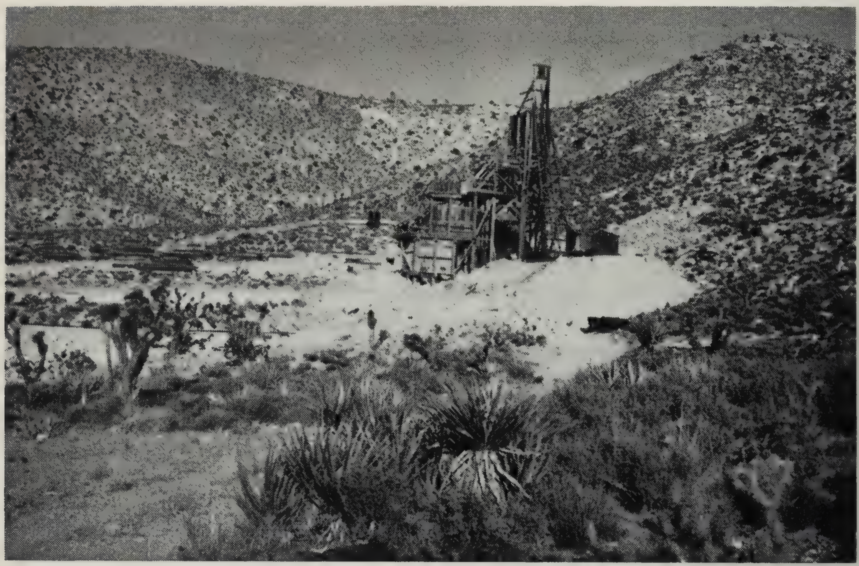

FIG. 14. Evening Star tin mine, near Cima. *Photo by Walter W. Bradley.*

Tin

Evening Star Mine (*tin*). It comprises 4 claims, known as the Bernice group, situated 1½ miles south of Standard No. 1 copper mine, on the north slope of the Ivanpah Mountains, in sec. 30, T. 15 N., R. 14 E., S.B., 9 miles north of Cima and 10 miles southeast of Valley Wells; elevation 5000 feet. Owners are Vaughn Maynard and Hiram Whisler, Santa Ana, California; under lease to C. F. Wendrich, Steel Service & Sales Company, Chicago. Ralph L. Reade is manager.

The country rock is a dolomitic crystalline limestone, with granitic outcrops to the south of the deposit. The limestone is traversed by two intersecting fissure veins making an angle of about 40 degrees with each other, the strikes being N. 70° W. and S. 70° W. The northwest vein is practically vertical; the southwest vein dips to the northwest. These veins vary from 2 feet to 7 feet in width. The calcite, with subordinate tremolite gangue, carries cassiterite and a small amount of scheelite.

Development consists of a shaft sunk at the intersection of the two veins, vertical for about 35 feet and then inclined 45° W. for about 70 feet. The highly iron-stained vein is up to 10 feet wide and is said to carry 2 percent tin. About 100 feet southeast is a vertical shaft 30 feet deep which has been sunk on the vein. In an open cut between these two shafts, the vein has been exposed for a length of 100 feet. The vein is from 2 to 4 feet in width. The vein material is limestone mineralized with cassiterite, associated with scheelite; also shows distinct flourine stains and carries chalcopyrite.

A shipment of 25 tons to the Tin Processing Corporation, Texas City, Texas, ran 6.27 percent tin.

Equipment at the mine consists of 60-foot head-frame, with 9-inch by 16-inch jaw crusher, Symons Cone crusher, 10-mesh screen to 10-inch by 16-inch rolls to 100-ton bin, capacity 10 tons to 15 tons per hour.

A gasoline-driven hoist and portable compressor complete the installation at the mine.

The mill which is at Windmill Station on U. S. Highway 91, is 10 miles north of the mine and consists of bin to elevator to hopper, by automatic Hardinge Feedometer to 2 Denver jigs to 2 Wilfley tables. Power is furnished by Fairbanks-Morse, one-cylinder, diesel engine, direct-connected to 30 KVA generator. Capacity of plant is about 30 tons per day. The concentrates are reported to carry 18 percent in.

Plant is shut down while sinking 30-foot shaft mentioned above. Eight men are employed.

Tungsten

Antelope tungsten mine, consisting of 3 claims, is in the San Bernardino Mountains on a ridge between Rattlesnake and Antelope Canyons, 5 miles south of Mound Springs, in sec. 33, T. 2 N., R. 3 E., S. B.; elevation 6000 feet; owners, L. Z. Bess, 890 Campus Way, San Bernardino, and Fuller Arthrup, Banning, California; leased to C. L. Harnage and L. Z. Bess, on the ground.

On the north slope of Antelope Canyon there are several remnants of limestone deposits which are in contact with the granitic basement. These contacts generally have a northeast strike and southeast dip and are marked by tactite bodies of various widths. On one of these contacts a hole about 8 feet wide and 12 feet deep has been dug in decomposed material. There are small stringers here which carry high-grade scheelite ore. These go down to the hard limestone about 8 feet below the surface but do not penetrate it.

The material taken from this hole was hauled 2 miles down Rattlesnake Canyon and treated in a mill consisting of 16-inch by 4-foot trommel, minus $\frac{1}{8}$-inch material to Economy table. Capacity is about 6 tons per day. Two men operated the property. Idle.

Argosy Tungsten Mine. It comprises 3 claims situated in the New York Mountains, in T. 11 N., R. 17 E., S. B., 6 miles north of Goffs, a station on the Santa Fe Railroad; owner, Mrs. V. R. Remalia, Los Angeles; elevation 6500 feet.

The ore, huebnerite and wolframite, is finely disseminated in a system of veinlets in a pegmatite dike. The veinlets vary in width from 4 to 6 inches; strike with general eastward trend of the dike, dip 45° N. Ore is reported to average 0.5 to 2 percent WO_3. Development consists of tunnel 140 feet long along the dike and a 38-foot raise to the surface; also shallow open cuts along dike. There was a small production in 1916-1917.

Bibl.: State Mineralogist's Reports XV, pp. 844-845; XXXVII, pp. 305-306.

Atolia Mining Company, P. R. Bradley, president; C. A. Norris, secretary; Hugh H. Coke, superintendent, 1022 Crocker Building, San Francisco, has temporarily shut down the flotation section of its mill at Atolia while installing pumps to deliver an additional 20,000 tons from another tailings pile. The gravity section of this mill is running on ores from the Amity, Union, and Papoose mines and from ten sets of leasers working at various places on the company's property. To keep this section of the mill up to its capacity of 250 to 300 tons per day, the table sands from the Union mill are being hauled to this plant.

Bibl.: State Mineralogist's Reports XV, pp. 830-839; XVII, pp. 370-372; XX, pp. 96-97; XXVII, pp. 365-366; Bull. 95, pp. 70-78 and 125-128.

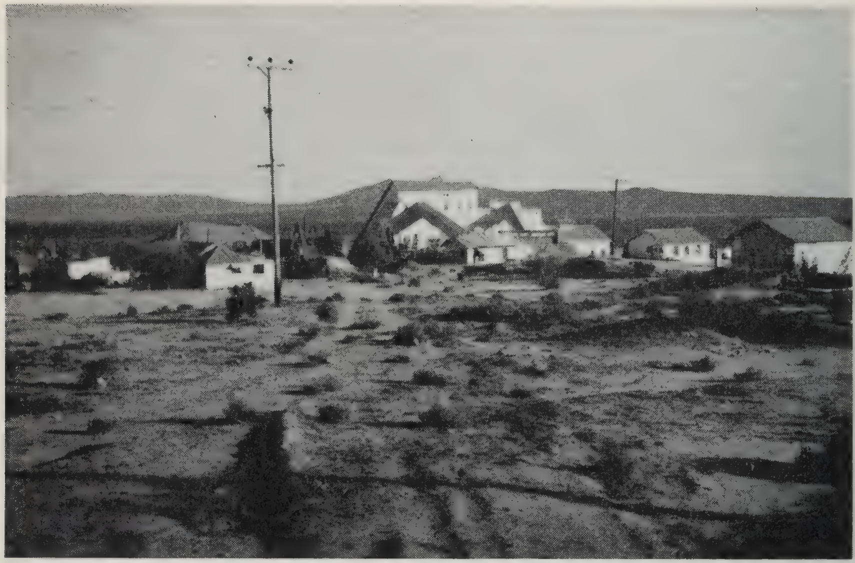

FIG. 15. Tungsten mill of Atolia Mining Company at Atolia. *Photo by Walter W. Bradley.*

Atolia Tung-Sun Placer Mining Company, Ray Schwietzer, general partner, 5633 Lexington Avenue, Los Angeles, has leased 12 claims in Baltic Gulch, just southwest of the Baltic mill, sec. 7, T. 30 S., R. 41 E., M. D., some 2 miles south of Randsburg.

This ground embraces Baltic Gulch and its tributaries from the west. The pay dirt in these gulches is said to average 100 feet wide by about 15 feet deep with no overburden. Sampling indicated 4.8 pounds of scheelite per yard; estimated minimum 250,000 cubic yards. The material is mined by $\frac{3}{4}$-yard boom drag, loaded into 5- and 10-ton trucks and hauled to the mill, 5 miles north of the deposit.

The plant consists of railroad rail grizzly, 10-inch by 10-inch openings, to steel hopper to reciprocating feeder to 30-inch belt conveyor, 100-foot centers on 19° inclination to 60-cubic yards steel bin, apron feeder to 52-inch by 19-foot trommel, 11-foot scrubber section, 5-foot $\frac{1}{2}$-inch screen and 3-foot $1\frac{1}{4}$-inch screen; oversize to 6-foot cone, to picking belt equipped with dark house section and ultra-violet ray light. Minus $\frac{1}{2}$-inch to Overstrom constant pressure up-current classifier, 9 feet in height to keep down slime losses; minus $1\frac{1}{4}$-inch, plus $\frac{1}{2}$-inch at present also goes to picking belt pending further research. Table tails go to Stephens-Adamson de-sander (water wheel type); all tails to stacker belt. The capacity is 300 cubic yards per day. All machines have individual motor drives.

A 655-foot well at plant, equipped with Pomona deep well pump, supplies water. Power is from California Electric Power Company. Eight men are working.

Blue Vase Tungsten Group of Mines. It comprises 5 claims situated in the Morongo mining district, on the east slope of the San Bernardino Mountains east of Rattlesnake Canyon, in sec. 2, T. 2 N., R.

3 E., S. B., 25 miles northeast of Warren's Well and 45 miles northwest of Whitewater; elevation 7000 feet; owner, William Baur, Los Angeles.

Scheelite occurs in narrow veins of quartz in schist along a shear zone that strikes north and dips 35° W. The width of the shear zone is about 40 feet and the formation is granite. Development consists of two open cuts and two shallow shafts about 20 feet deep. Idle.

Bibl.: State Mineralogist's Report XXXVII, p. 584.

Bonanza Dome and Beacon tungsten mines, Hewitt S. West, president, Pasadena, California; James I. Moore, San Bernardino, California, have had a lease on the Pride of Mojave mill, sec. 6, T. 7 N., R. 6 W., and sec. 32, T. 8 N., R. 6 W., S. B., 4 miles south of Mojave and also 12 mining claims owned by Geo. A. Barrington, in the South Field of El Mirage Lake tungsten district, about 10 miles northwest of Adelanto.

The ore occurs at the contact of limestone with a gneissoid granite. The general strike is northwest. The lenses are short but may be quite high grade. The gangue is largely garnet and epidote. One peculiarity is the occurrence of thin coatings of scheelite on faces of calcite crystals which may be as much as 5 inches across. The lenses are up to 6 feet wide.

Development consists of open cuts and a 75-foot vertical shaft on the Bonanza Dome claim. On the 50-foot level, drift west 30 feet where a winze was sunk 25 feet. Small lenses of high-grade ore were encountered in these workings. About half a mile northeast a shaft was sunk 35 feet on a contact of schist and lime. This shaft was sunk at a small open cut from which some high-grade ore was taken.

Between September 1942 and February 1943, the company shipped between 600 and 700 tons to the mill at Mojave which is reported to have averaged 0.5 percent WO_3.

The company relinquished both of its leases in February, 1943. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 59.

Brooke Molybdenite and Tungsten Mine. (See also *Big Hunch Mine,* page 497.) It comprises 4 patented claims known as Omega, Beta, Big Hunch, and Big Hunch No. 1, situated on the south slope of the New York Mountains, in sec. 35, T. 14 N., R. 15 E., S. B., 6 miles south of Ivanpah, a station on the Union Pacific Railroad; owners, J. F. Brooke and F. M. Brooke, Barstow; under option to H. H. Pike, San Bernardino, California.

Crystals of huebernite and wolframite occur, associated with molybdenite, irregularly disseminated throughout a pegmatite dike. The dike ranges from 25 to 60 feet in width. The dike strikes N. 75° W. and dips south. Average ore developed is reported to carry 0.5 percent WO_3. Development consists of crosscut tunnels on vein dike and a shaft 250 feet in depth.

Bibl.: State Mineralogist's Report XXXVII, p. 584.

Dorr Tungsten Mine. It comprises 3 claims situated in the New York Mountains, in sec. 36, T. 14 N., R. 15 E., S. B., 12 miles east of Cima, a station on the Union Pacific Railroad; elevation 6800 feet; owner, J. C. Dorr, San Bernardino, California. The property is leased to United States Tungsten Corporation, Warren T. Potter, president, Altadena, California.

The country rock is granite. The deposit consists of quartz of magmatic segregation origin, through which is disseminated huebernite. Its strike is northwest, dip 55° SW. The width is up to 80 feet and outcrops for a distance of several hundred feet.

Development consists of a shaft 140 feet in depth, with levels at 40 feet and 140 feet. At 150 feet below the collar of the shaft, an adit has been driven west 100 feet. Ore is being mined from open cut south of the shaft. This ore is reported to carry from 0.5 to 1 percent WO_3.

An incline, single-track tram, 650 feet long, lowers ore from mine to a 50-ton bin. From bin, ore is hauled by truck two miles to concentration mill having a capacity of 40 tons. Five men are employed.

Bibl.: State Mineralogist's Report XXXVII, pp. 584-585.

Gillsmith and Victory Group of Tungsten Mines. It comprises 4 claims situated on the northwest slope of the New York Mountains, in sec. 17, T. 14 N., R. 15 E., S. B., 4 miles southeast of Ivanpah; elevation 4600 to 5000 feet; owner, H. S. Gillies, Los Angeles.

Scheelite occurs in quartz veins, associated with fluorite. The veins occur on contact of granite and limestone. Veins range in width from 12 inches to 3 feet. Development consists of a shaft 10 feet deep and a tunnel 65 feet in length. Idle.

Bibl.: State Mineralogist's Report XXXVII, p. 585.

Gold Basin (formerly Elkhorn Mining Company; Silver Basin), consisting of 7 claims and fractions, is in sec. 7, T. 30 S., R. 41 E., M. D., 2½ miles southeast of Randsburg; elevation 3600 feet; owner, Gold Basin Mines, Clarence Barker, president, Los Angeles.

On this property, formerly worked for its gold content, there are two parallel quartz veins in the schist, strike northwest, dip 70° NE., from 12 inches to 3 feet wide. There is also a series of north-trending fractures which are from 5 feet to 6 feet wide, filled with brecciated wall rock, recemented with quartz.

Development consists of a 240-foot shaft on Hidden Treasure claim and 200-foot shaft on New Era claim. At present work is confined to the New Era claim. On the 125-foot level a drift is being driven northwest which is now in 225 feet from the shaft. There is a small underhand stope here about 75 feet long by 12 feet to 15 feet deep. These workings are connected with the third or bottom level by a 70-foot raise.

The mill at the New Era shaft consists of 9-inch by 12-inch crusher, belt conveyor to trommel, ¼-inch screenings to jig, oversize to 16-mesh trommel screen, screenings to jig, tails to tables, oversize to elevator to bin to belt feeder to Hendy rod mill 5 feet by 14 inches to elevator to 4-foot cone to jig; hutch product to elevator to 2 tables, cone overflow to jig tails.

A little ore from the Stringer district has also been treated in this mill. Water is piped from the Big Butte mine in Randsburg. Five men are employed on development work.

Bibl.: State Mineralogist's Reports XIX, p. 169; XXVII, pp. 293-294.

Hidden Value and Victory Tungsten Mines. The property comprises two groups of claims situated in the south end of Old Woman Mountains. The Hidden Value group comprises 13 claims situated in sec. 8, T. 5 N., R. 17 E., and the Victory group comprises 8 claims in sec. 6, T. 5 N., R. 17 E., S. B., 16 miles southeast of Danby, a station on the

Santa Fe Railroad; elevation 3450 to 4350 feet; owners, Mrs. M. M. Richardson and L. J. Rouchleau, Los Angeles.

The formation in which these scheelite deposits occur is limestone, schist, and gneissoid granite. The limestone beds strike N. 40° E. and dip 35° to 40° NW. The mineralized belt is about two miles in length and about 1000 feet in width. On the Hidden Value group of claims to the southwest there is a belt of limestone, then a belt of tactite with intrusions of schist and granite and a belt of schist and gneissoid granite. In the belt of tactite which strikes northeast and dips 30° NW., there are irregular, lenticular outcrops of epidote mineralized with scheelite from 10 to 20 feet in width and from 70 to 100 feet in length. These outcrops occur at intersection of north-trending fractures that cut the tactite.

On No. 4 Hidden Value claim are four parallel outcrops of tactite, the largest outcrop being near the top of the ridge. This outcrop is 15 to 20 feet in width and about 100 feet in length and parallel to it, within 130 feet to the southwest are 3 parallel outcrops. Samples taken from different outcrops are reported to assay from 1 to 3 percent WO_3. The three parallel veins mentioned are 10 to 15 feet in width and about 50 to 75 feet in length. The veins strike northeast and dip 30° to northwest. On No. 3 Hidden Value claim to the southwest of No. 4 claim, there is a massive lens of tactite 75 feet in length and 15 feet wide. Also, on No. 2 Hidden Value claim adjoining No. 3 on the southwest, are several large outcrops of tactite stated to be 75 to 300 feet in length and 20 feet in width. Samples taken from outcrops on No. 2 claim are reported to carry from 1 to 3 percent WO_3. On Hidden Value No. 5, there is a massive outcrop of epidote rock reported to be 300 feet in length, with an average width of 15 feet. The samples taken from this outcrop are reported to carry 0.5 to 1 percent WO_3.

On Victory group of claims the scheelite occurs along intersecting fractures in gneissoid granite. Present development is confined to the Hidden Value group of claims and the owners have received a development loan of $20,000 from the Reconstruction Finance Corporation for the development of this group of claims. A large proportion of this money has been spent on building roads to Hidden Value No. 4, Hidden Value No. 2, and Hidden Value No. 5 desposits. The present plan is to mine the ore from four veins on Hidden Value No. 4, and six men are now employed in the construction of a jig-back aerial tram 2750 feet in length. At loading terminal, there is a bin with a capacity of 125 tons.

The operators plan to haul the ore by truck to Siam, a station on the Santa Fe Railroad, a distance of 18 miles, for shipment to the Metals Reserve Company at Salt Lake City. The owners are confident they can mine and ship ore that will run 1½ percent WO_3.

Howe Tungsten Mine. It comprises 640 acres of patented land situated in the south end of Old Woman Mountains, in sec. 9, T. 5 N., R. 17 E., S. B., 16 miles southeast of Danby, a station on the Santa Fe Railroad. The property adjoins the Hidden Value group of tungsten claims on the northeast; owner, George Howe, 1198 South San Pedro Street, Los Angeles; under lease to Walter Zindell and John Tunney, Essex, California; elevation 4300 feet.

The formation is limestone, gneissoid granite, and schist. The scheelite occurs in tactite on contact of limestone and granite. The lens of epidote rock mineralized with scheelite is said to be 150 feet in length, with a width of 6 to 10 feet. The orebody strikes northeast, dips 30° NW.

Installation of a jig-back tram 1800 feet in length, from deposit to terminus of road north of Hidden Value ore bin, is planned. Three men are employed.

May Day mine comprising 9 claims is on the northeast end of Ord Mountain, 15 miles southeast of Daggett, a station on the Santa Fe and Union Pacific railroads, in sec. 7, T. 7 N., R. 3 E., S. B.; elevation about 4400 feet; owner, Joseph McGalliard, Daggett, California; under bond and lease to Aztec Mines, Inc., Henry Scheinbaum, secretary and treasurer, 522 South Alameda Street, Los Angeles.

The main body of the ridge on which these claims are located consists of diorite and monzonite. There are also some east-trending rhyolite dikes. Two lime-magnesium, silicate dikes about 180 feet apart traverse the country N. 20° W. Between these two dikes there is a series of parallel garnet-epidote veins, strike N. 20° W., dip about 68° SW., carrying undetermined average values in WO_3 where crossed by east-trending fractures. Where exposed they range from 3 feet to 8 feet in width.

Development consists of several small open cuts, one of which is 20 feet long, 8 feet wide, with a maximum depth of 10 feet. The 8-foot width is said to average $1\frac{3}{4}$ percent WO_3. Forty feet southeast of this cut a shaft has been sunk on 55° W. 35 feet. In this length three garnet-epidote streaks 3 feet to 4 feet wide, dipping about 70° SW. were encountered. A few more feet should reach the vein on which the open cut was made above.

The company has bought the camp and mine equipment from Symons Bros. Development Company which they had at the Ord Mountain mine. The four men employed are now engaged in moving this camp and equipment onto their property.

Mojave tungsten mine, comprising 11 claims, is in the Clark Mountain mining district, on the northwest slope of Clark Mountains, in sec. 19, T. 17 N., R. 14 E., S. B., 10 miles north of Valley Wells; elevation 5500 feet; owner, Colosseum Mining & Smelting Corporation, C. H. Gowman, president and manager, 7371 Sunset Boulevard, Hollywood, California.

The vein occurs in quartz monzonite, strike east, dip 85° S., width 4 feet. The vein-filling is quartz and calcite through which is disseminated wolframite and a minor amount of scheelite. There is a 12-inch to 18-inch streak of high-grade on the hanging wall. The vein is traceable on the surface for 1000 feet. One ore shoot east of the shaft, 75 feet in length, has been developed and two others west of the shaft are indicated by samples taken from the outcrop. These ore shoots form at the intersection of cross fractures which strike N. 25° W. The samples from the outcrop ran from 0.5 to 2.0 percent WO_3. Sample across 4 feet in the shoot developed, reportedly ran 0.71 percent WO_3, with 12 inches on hanging wall carrying 5 percent WO_3.

Development consists of shaft sunk on the vein 170 feet, on 50-foot level, drift east 200 feet, west 90 feet; on 100-foot level, drift east 200 feet; on 150-foot level, drift east 50 feet. The 75-foot ore shoot east of the shaft was stoped from the 100-foot level to surface, with an average width of 4 feet.

The property was operated from 1915-1918 by Mojave Tungsten Company, Foster G. Maetling, general manager, 165 Broadway, New York. They operated a 10-ton, gravity concentration plant and produced 60,000 pounds of 60 percent WO_3 and 4000 pounds of 50 percent WO_3 concentrates. Idle at present.

Osdick Group of Tungsten Mines. It comprises 7 claims situated in the Atolia mining district, east of the Atolia Mining Company's property, in secs. 20, 21, T. 30 S., R. 41 E., M. D., half a mile east of Atolia; elevation 3175 feet. Owner is P. J. Osdick, Red Mountain, California.

Two veins in monzonite have been developed on these claims known as the Big Ben and Skylark. The Big Ben vein strikes Northeast, dips 75° N.; width 6 inches to 12 inches. A shaft is sunk on the vein to a depth of 185 feet. The Skylark vein strikes Northwest, dips 70° N.; width 6 inches to 2 feet. The Skylark shaft has been sunk on the vein to a depth of 165 feet, with drifts on three levels. These workings have been the most productive on the property. Production is reported to have been $250,000.00. The property was under operation in 1943 by the West Development Company, Los Angeles. Idle.

Bibl.: State Mineralogist's Report XXXVII, pp. 288-289.

Paradise Mountains Tungsten Deposit. It comprises 10 claims situated in the south end of Paradise Mountains, 3 miles northeast of the Olympus mine, in secs. 6 and 7, T. 12 N., R. 2 E., S. B., 25 miles northeast of Barstow; owner, P. R. Hetherington, Los Angeles; elevation 3000 feet.

Scheelite occurs in tactite on contact of granite and dolomite. The vein on the contact has a width of 4 feet and ore is reported to carry from 1 to 2 percent WO_3. Development consists of open cuts and a shaft 10 feet in depth. Idle.

Bibl.: State Mineralogist's Report XXXVII, p. 585.

Shadow Mountains deposits are on the north and south slopes of these mountains from 15 to 20 miles northwest of Adelanto, in secs. 30, 31, T. 8 N., R. 6 W., S. B. The north slope deposit is owned by Shadow Mountain Tungsten, Inc., Just Associates, E. Richard Just; Oliver Adams, manager, 715 Commercial Exchange Building, Los Angeles; it was under lease to Rasmussen and Trout, Macco Construction Company, Clearwater, California.

The Shadow Mountains are largely composed of granite which has been intruded into a series of limestone beds converting them into a garnet-epidote-calcite marble. Scheelite occurs in fractures in the limestone near its contact with the granite. The lessees did extensive trenching and sampling of these claims after which they built a 100-ton mill and ran some 500 tons which averaged 0.35 percent WO_3. This content being too low at that time for profitable operation, the plant was removed and the property reverted to the owners.

Bibl.: State Mineralogist's Report XXXVII, pp. 316-317.

Silver Star Group of Tungsten Mines. It comprises 5 claims situated in the Ivanpah Mountains, in Mescal mining district, in secs. 6 and 7, T. 15 N., R. 14 E., S. B., 12 miles north of Cima; elevation 5000 feet; owners, Chas. H. Richards and C. E. Hammett, Lawndale, California.

The country rock is limestone and granite with some diorite dikes. Scheelite occurs in vein form 6 inches to 12 inches wide, the vein quartz being stained with copper oxides. The vein strikes N. 20° W., dip vertical. Developed by open cut and shallow shaft 10 feet in depth. Idle.

Bibl.: State Mineralogist's Report XXXVII, p. 585.

Spud Patch Placer. Hoefling Bros., P. O. Box 786, Sacramento, California, have a lease on about 200 acres, comprising the entire Spud Patch, about a mile southeast of Atolia. Allen E. Jones is in charge of operations.

This ground was intensively worked during World War I, when many tons of scheelite were produced by hand work. The material recovered from the sand and gravel of this area was almost pure scheelite in rounded pieces from the size of a walnut or smaller to those weighing almost a hundred pounds. In this area which is something over a mile long and more than a quarter of a mile wide, there is from 8 feet to 40 feet of overburden under which is the pay streak averaging about 3½ feet in thickness. There is no real bedrock, the material underneath being similar to the overburden. Boulders weighing 200 pounds or more are very scarce. The pay streak is sand and fine gravel, 80 percent of which will go through a 10-mesh screen; there is less than 10 percent slime. As in practically all placer deposits, there are, in places, concentrations of values greater than the average. These are believed to occur along the course of old stream beds.

The ground is stripped and mined by a bulldozer which delivers the material to one 2-yard and one 1½-yard dragline shovel by which it is loaded into trucks and hauled 4 miles northeast to the washing plant on the slope west of Cuddeback Dry Lake. Here it is dumped either into a 30-ton hopper or on a stock pile. From the stock pile, a tractor with blade delivers it to hopper as needed. From the hopper by pan feeder to 6-foot by 25-foot trommel with a 10-foot scrubbing section, ⅝-inch, with 10-mesh jacket screen; minus 10 pumped to 2-cell Pan American jigs, the hutch from which goes through Triton continuous amalgamators and then over a Straub table. The minus ⅝-inch plus 10-mesh goes to a 2-cell Bendelari jig, hutch back to 10-mesh circuit; plus ⅝-inch minus 1-inch goes to a 2-cell Bendelari jig. The plus 1-inch from trommel goes to tailings stacker belt over a section of which is built a ''dark room'' in which a large ultraviolet ray light is mounted over the belt. Two men pick spuds from the belt. This plant is a converted boat which formed part of a dragline dredge.

Water is obtained from 3 wells, ½-mile, 1 mile and 1½ miles distant. Deep well pumps deliver the water to a reservoir 125 feet in diameter in which about 8 feet of water is stored. The plant has a capacity of 70 yards per hour and is operated at capacity 10 hours each day. Electric power is supplied by Southern Sierras Power Company.

Fifteen men are now working. A full crew would consist of 20 men.

Bibl.: State Mineralogist's Reports XV, pp. 830-839; Bull. 95, pp. 144-145.

Standard Tungsten Mine. It comprises 6 claims situated in the Ivanpah Mountains, Mescal mining district, in sec. 18, T. 15 N., R. 14 E., S. B., 10 miles north of Cima, a station on the Union Pacific Railroad and 10 miles southeast of Wind Mill Station on U. S. Highway 91; elevation 5000 feet; owner, Riley Bembrey, Cima, California. During the latter part of 1941, the property was under lease to W. W. Hartman, Los Angeles.

Scheelite occurs in tactite on the contact of crystalline limestone and monzonite. The tactite is from 15 to 40 feet wide and some 600 feet in length. Its general strike is northeast.

Development work consists of a series of trenches across the tactite orebody for a distance of 600 feet. About 500 feet southwest of the Old Standard No. 2 shaft, there is a large trench 60 feet in length and 10 feet in depth; also a tunnel 60 feet in length. The ore mined by W. W. Hartman was hauled to the Valley View mill for concentration. Ore treated is reported to carry from 0.5 to 2 percent WO_3. Two men are employed.

Sunnyside Tungsten Mine (Livingstone and Morongo King) (gold-tungsten). It comprises 10 claims situated on the east slope of the San Bernardino Mountains, in Morongo mining district, in sec. 27, T. 2 N., R. 3 E., S. B., 22 miles northwest of Warner's Well and 44 miles northwest of Whitewater; elevation 5500 to 6000 feet; owners, G. M. Bussey and E. F. Bain, Whitewater, California.

In the latter part of 1941, scheelite was discovered in the Morongo King quartz vein and along a bed of tactite parallel to the quartz vein. The Morongo King vein strikes northeast for a distance of 800 feet, then has a north-trending strike, dip 35° W. Width is 6 to 8 feet. The footwall is granite with a narrow bed of limestone as a hanging wall. The vein material is made up of a quartz vein 12 inches thick on the hanging wall and quartz stringers in schistose material. The vein quartz is mineralized with free gold, associated with pyrite, with minor amounts of scheelite crystals.

Northwest of the gold vein, on ridge above the Morongo King shaft, are two roughly parallel beds of tactite in granite, lying between a narrow bed of limestone and a massive belt of limestone. These tactite beds strike northeast and dip 35° NW. The beds of tactite have a thickness of 6 to 10 feet. The tactite is mineralized with scheelite. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 504; IX, p. 227; XII, p. 320; XV, p. 800; XXXVII, pp. 586-587.

United Tungsten Copper Mines. It comprises 3 claims situated on the eastern slope of the San Bernardino Mountains, Morongo mining district, in sec. 28, T. 2 N., R. 3 E., S. B., 50 miles southeast of Victorville; elevation 6500 feet. From 1916 to 1918, the property was owned and operated by United Tungsten Copper Mines Corporation and a small production made from the property. Owners are Bert Johnson Bundage and P. S. Noon, Los Angeles.

The orebody is a scheelite-bearing contact metamorphic deposit. The country rock is a fine-grained biotite granite, intruded into a marbleized limestone. The limestone beds are about 10 feet in thickness. The scheelite occurs in garnet-epidote rock on intersection of north-trending fractures which cut across the east-trending limestone beds that dip south.

Development consists of a tunnel driven S. 40° W. in granite to contact of limestone 200 feet in length with drift on contact 50 feet. Ore developed has an average width of 2 feet. Ore shoot worked was about 50 feet in length. The scheelite is generally coarsely crystalline and often occurs in quartz associated with the epidote. The ore mined by former operators is reported to carry 2 percent WO_3. Idle.

Bibl.: State Mineralogist's Report XXXVII, p. 317.

Nonmetallic Minerals

The rapid industrial growth of the City of Los Angeles in recent years has created an increased demand for both industrial and structural materials, especially due to the conversion of some industrial plants for the manufacture of parts and equipment for the war effort. Los Angeles is also the center of the aviation industry on the Pacific Coast and with the expansion of the ship-building industry, also the iron and steel industry, has created a demand for raw materials. San Bernardino County has a great variety of commercial minerals. The more important of these minerals are barite, bentonite, clay, dolomite, limestone, silica, and talc. Cement is the most important single structural material in the mineral output of San Bernardino. Three plants were under operation in 1943 and the production was the largest on record. The largest production of bentonite in the state was from Hector, San Bernardino County. The 1942 output of talc was the largest in years, both in amount and value, and came from three properties.

Asbestos

Deposits of asbestos of the amphibole variety occur in the desert regions of the county.

Cronese Asbestos Deposit. It comprises 4 claims situated 10 miles south of Baker, in sec. 14, T. 12 N., R. 9 E., S. B.; owner, A. B. McAntire, Los Angeles. The chrysotile and amphibole varieties of asbestos occur in dolomitic limestone, along a belt of serpentine. Undeveloped.

Bibl.: State Mineralogist's Report XXVII, p. 370.

Golconda Asbestos Deposit (Hicks). It comprises 640 acres situated in sec. 36, T. 9 N., R. 4 W., S. B., 4 miles northwest of Hodge, a station on the Santa Fe Railroad; elevation 2500 feet; owner, W. E. Leahy, Los Angeles; under lease to Golconda Petroleum Corporation, 210 West Seventh Street, Los Angeles.

The amphibole variety of asbestos occurs along a belt of serpentine which strikes northeast and the outcrop is exposed by open cuts and shallow trenches for a distance of a mile. The width of serpentine mineralized with amphibole is about 20 feet. The material mined from open cuts is ground and screened to 10-mesh to 20-mesh size and sacked for shipment. About 200 sacks of material are stored on the property.

The property was operated by the present company in the early part of 1943; 6 men were employed. Idle.

Bibl.: State Mineralogist's Reports IX, p. 286; XV, p. 852; Bull. 38, p. 263.

Barite

Ball Barite Deposit. It comprises 6 claims situated 15 miles north of Barstow, in sec. 20(?), T. 12 N., R. 2 E., S. B.; owner Red Seal Chemical Company, O. H. Ball, president, Los Angeles.

A vein of white barite occurs in andesite, strike northwest, dip 80° SW; width 4 to 6 feet. Barite is white in color, gravity 4.22 to 4.33. It is reported to be of chemical grade. Development consists of open cuts and shallow shafts. Idle.

Barium Queen mine comprises 3 claims situated in secs. 22 and 27, T. 10 N., R. 1 W., S. B., 5 miles northeast of Barstow; elevation 3000 feet; owner, Ellis Mallery, Los Angeles.

A series of parallel veins occurs in quartzite and schist, strike N. 30° W., dip 70° NE. The vein developed is from 4 to 5 feet wide and the outcrop can be traced on surface for 4500 feet. Development consists of tunnel 250 feet in length and a number of shallow shafts 20 to 60 feet in depth. Idle.

Bibl.: State Mineralogist's Report XVII, p. 334.

Big Medicine Barite Deposit. It comprises 2 claims situated 6 miles northeast of Barstow and 1½ miles south of Lead Mountain, in sec. 3, T. 10 N., R. 1 W., S. B.; owners, George Parks and Dr. W. M. Smith, Barstow, California.

A vein of iron-stained barite occurs in dolomitic limestone, near contact of gneissoid granite; strike N. 45° W., dip 30° NE.; width 4 to 6 feet. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 371.

Hansen Barite Deposit. It comprises 4 claims situated 3½ miles north of Ludlow, in sec. 30, T. 8 N., R. 8 E., S. B.; owner, Harry B. Hansen, Ludlow, California. A vein of barite occurs in basalt, strikes N. 45° W., dip 45° NE.; width 4 to 14 feet. Developed by a tunnel 250 feet in length. Some 60 cars of ore have been shipped from the deposit. Idle.

Bibl.: State Mineralogist's Reports XXVI, pp. 54-55; XXVII, pp. 371-372.

Lead Mountain Mine. (See under lead-silver).

Bentonite

Deposits of bentonite of commercial importance occur near Hector, in T. 9 N., R. 5 E. and T. 8 N., R. 5 E., S. B., the principal producer in this area being the California Talc Company, a subsidiary of the Natural Pigments & Chemical Division of National Lead Company. The Hector deposits have been under production since 1931. There are other deposits of commercial importance situated in the Old Dad Mountains, Bitter Springs district and in Red Mountains district, there being two producers in the latter district.

Balch Bentonite Deposit. It comprises 6 claims situated in Old Dad Mountains, 10 miles northeast of Balch, a station on the Union Pacific Railroad, in sec. 10, T. 12 N., R. 11 E., S. B.; owner, Edward Sexton, of Los Angeles. The clay beds have a thickness of 10 feet. Development consists of open cuts. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 379.

Barber Bentonite Deposit. It comprises 320 acres situated near Bitter Springs, 18 miles north of Harvard, a station on the Union Pacific Railroad, in sec. 6, T. 13 N., R. 4 E., S. B.; owner, A. M. Barber, Los Angeles. The bed of bentonite is 100 feet thick and can be traced along the surface exposures for 3000 feet. The bentonite is white in color and of good quality. Development consists of two open cuts. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 380.

California Talc Company's Bentonite Deposits. The property comprises fourteen 160-acre placer claims, approximately 2200 acres, situated in sec. 31, T. 9 N., R. 5 E. and in secs. 22, 23, 24, 26 and 27, T. 8 N.,

R. 5 E., S. B. The Lemon or south deposits are located in secs. 26 and 27, T. 8 N., R. 5 E., 3 miles south of Hector, and the north deposits are located 3½ miles west of Hector, a station on the Santa Fe Railroad; elevation 2000 feet; owners, National Pigments & Chemical Division of National Lead Company. Local office is located at 830 Ducommon Street, Los Angeles; George L. Radcliffe, president and manager; Percy Staudinger, superintendent.

The present production is entirely from the south deposit. It is a bedded deposit of bentonite that is covered by a flow of basalt. The beds strike east, dips range from 5° to 20° to south. The thickness of the bentonite beds is from 6 to 40 feet. The basalt overlying the beds of bentonite is from 12 to 15 feet thick. The bentonite mined is white to gray in color and contains a high magnesium content.

The present incline shaft is sunk on limestone footwall on an inclination of 12° to a depth of 300 feet. This shaft is located 500 feet south of old shaft and open cut. The bed of bentonite developed is from 8 to 10 feet in thickness, with 5 feet of white bentonite on the footwall and 4 to 5 feet of brown bentonite underlying the hanging wall of clay which is overlain by basalt. There are two drifts west from shaft and four drifts to the east at different elevations. On the 300-foot level drift northwest 300 feet connecting with workings from old shaft. The present production amounts to 25 tons per day. The bentonite mined is hoisted by 15-horsepower gas engine hoist to bunkers. From bunkers, the material is loaded into trucks and hauled to drying platform at Hector Siding. The material is sun-dried then loaded into railroad cars for shipment to the company's grinding plant in Los Angeles. Six men are employed.

Bibl.: State Mineralogist's Reports XXVII, pp. 380-381; XXXVI, pp. 81-82, 250-253.

Ewrite Deposit. It comprises a 160-acre placer claim situated in sec. 35, T. 8 N., R. 5 E., S. B., 3 miles south of Hector, and adjoins the California Talc Company's deposit on the south and west; elevation 2000 feet; owner, Oscar H. Horner, Newberry, California; under lease and option to F. E. Schundler, Joliet, Illinois, C. P. Durleth, superintendent.

The bed of bentonite strikes northwest, dips 5° to 10° SW. Thickness is from 6 to 8 feet. It is developed by a 2-compartment vertical shaft 72 feet in depth. Past production amounts to 500 tons. Plan to ship bentonite to Chicago, Illinois. Four men are employed.

Bibl.: State Mineralogist's Report XXXVI, p. 253.

Pacific bentonite deposit, comprising 5 claims and a fraction, in secs. 29 and 30?, T. 28 S., R. 41 E., M. D., is 8 miles north of Johannesburg west of the Trona road. Owner is Luis Martinez, Red Mountain, California.

The deposit consists of from 5 feet to 12 feet of light green bentonite, dipping approximately 35° N. It is a good grade of material, said to absorb twenty times its volume of water.

Besides numerous shallow pits, the deposit has been developed by two shafts 100 feet and 65 feet deep. From these workings between 1000 tons and 1500 tons have been shipped to Kennedy Minerals Company, 2550 East Olympic Boulevard, Los Angeles. The owner mines and ships the material from time to time, as the orders come in.

Smith Bentonite Deposit. It comprises two 160-acre placer claims known as Black Prince group situated in sec. 26 (?), T. 6 N., R. 14 E., S. B., a mile northeast of Summit Service Station on U. S. Highway 66 and 5 miles northeast of Chambless; elevation 1600 feet; owners, D. N. and J. A. Smith and R. J. McPhillips, of Los Angeles. Beds of bentonite occur in basalt. The beds are 4 to 7 feet thick. The bentonite is white to pink in color. Development consists of a number of shallow open cuts and trenches. The bentonite is sold for a conditioner in chicken and cattle feed; also for beauty face pack. Idle.

Clay

Deposits of high-grade clay occur at a number of locations in the county. A plastic kaolin of exceptional quality has been developed on a number of deposits in the Hart Mountains in the northeastern end of the county near the boundary line of the State of Nevada.

Coors Kaolin Deposit. The property comprises 7½ claims situated in secs. 13 and 24, T. 14 N., R. 17 E., S. B., at Hart; elevation 5500 feet; owner, H. F. Coors, Inglewood, California. The beds of clay have a thickness of 20 to 25 feet. The clay is white-burning ball clay, possessing properties of china clay and ball clay. The clay was shipped to the plant of H. F. Coors at Inglewood, California. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 373; Bull. 99, p. 194.

Golconda Clay Deposit. It comprises 640 acres, patented, situated in sec. 36, T. 9 N., R. 4 W., S. B., 4 miles northwest of Hodge, a station on the Santa Fe Railroad; elevation 2500 feet; owner, W. E. Leahy, 4238 Edgehill Drive, Los Angeles. The property is under lease to Golconda Petroleum Corporation, 210 West Seventh Street, Los Angeles, William Spencer, president and manager.

A bed of clay occurs in rhyolite, south of serpentine belt. The thickness ranges from 10 to 20 feet. The clay is white to buff in color. It is developed by open cut 50 feet in length. Idle.

Holliman and Murphy Clay Deposit. It comprises a group of 12 claims situated in sec. 14, T. 12 N., R. 14 E., S. B., 7 miles southeast of Cima; owners, R. H. Holliman and D. Murphy, Cima, California. There are three distinct beds of white, semi-plastic clay, each 6 to 15 feet in thickness. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 374; Bull. 99, p. 195.

Le Feure Clay Deposit. It comprises 12 claims located in sec. 26, T. 6 N., R. 14 E., S. B., 16 miles east of Amboy. The clay beds have a thickness of 14 feet. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 374.

Marter White Clay Deposit (Velvet White). The deposit comprises the Velvet White placer claim, 160 acres, situated in the N½ NW¼ sec. 35 and the E½ NE¼ sec. 34, T. 7 N., R. 4 W., S. B., 3½ miles north of Bryman, a siding on the Santa Fe Railroad; owners, Mrs. Beryll Driscoll and Mrs. Dorothy L. Gordon, Los Angeles; under lease to Marter-White Mines, Inc., Lawrence B. Martin, president; McK. M. Paul, secretary; R. M. Richter, vice president and manager, 530 West Sixth Street, Los Angeles.

The clay is a feldspathic aluminum silicate, white to gray in color. It occurs in lenses in felsitic rock, strike N. 40° W. Average thickness of clay beds is 25 feet. The overburden is from 4 to 9 feet thick. Development consists of an open pit 200 feet in length and from 50 to 100 feet in width and 25 feet in depth. In mining the material, the overburden is first stripped off. The material being soft, it is loaded direct into trucks for shipment to Los Angeles. The present company put down eight drill holes to depths of 25 and 30 feet to prove the extent of the deposit. Estimated tonnage of white aluminum clay which is available is stated to be 150,000 tons.

Analysis by Atkins & McRae, Los Angeles:

Silica (SiO_2)	71.27%
Alumina (Al_2O_3)	14.65%
Iron (Fe_2O_3)	2.28%
Calcium oxide (CaO)	1.80%
Magnesium oxide (MgO)	1.30%
Soda (Na_2O)	0.29%
Potash (K_2O)	4.42%
Ignition loss	3.11%
Total	99.12%
Water soluble chloride	0.11%

From 1910 to 1933 the deposit was operated by Velvet White Filler Company, of Los Angeles, who had a crushing and grinding plant at Bryman Siding producing both air float and water float material. The material was sold to paint, soap and rubber manufacturers as a filler.

In 1940, the property was taken under lease by Velvet-White Company, of Los Angeles, B. N. Murphy, president, and operated until March 1943, when it was acquired by the present company. The company is shipping crude material to Muroc Clay Company's grinding plant at Los Angeles, where it is ground to minus 325 mesh, then sold to soap, paint, and rubber manufacturers. Three men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 861-862; XVII, p. 338; XXVII, p. 375.

Millet Clay Deposit. The deposit is situated in the W½ sec. 31, T. 9 N., R. 3 W., S. B., 3 miles west of Hicks, a station on the Santa Fe Railroad; owner, Kennedy Minerals Company, J. J. Kennedy, Los Angeles. The clay bed is 10 to 20 feet thick. The clay is white to buff in color. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 374; Bull. 99, pp. 195-196.

Siberia Clay Deposit. It comprises 320 acres situated in low, rolling hills in sec. 4, T. 6 N., R. 9 E., S. B., 2½ miles west of Siberia, a station on the Santa Fe Railroad; elevation 1500 feet; owners, George Benjamin, William Melrose and associates, Amboy, California.

The clay beds occur in rhyolite, capped with basalt. The beds are 50 to 100 feet thick. General strike of the beds is northeast. Development consists of open cuts and a series of shallow shafts. Analysis by Smith-Emery Company is as follows:

Alumina (Al_2O_3)	35.4 %
Silica (SiO_2)	60.0 %
Iron (Fe_2O_3)	0.96%
Calcium oxide (CaO)	0.18%
Ignition loss	1.20%
Total	99.90

Standard Sanitary Company's Deposit. The deposit is situated half a mile south of Hart, in sec. 24, T. 14 N., R. 17 E., S. B.; owner, Standard Sanitary Company, Richmond, California. The clay beds are 60 to 70 feet in thickness. The clay is hauled by truck to Ivanpah, a station on the Union Pacific Railroad. The production amounts to 15 tons per day. Four men are employed.

Bibl.: State Mineralogist's Report XXVII, pp. 374-375; Bull. 99, pp. 196-198.

Feldspar

White Butte feldspar deposit comprises 2 claims in sec. 16, T. 31 S., R. 44 E., M. D., about 20 miles southeast of Atolia. Owner is Gladding McBean & Co., 2901 Los Feliz Boulevard, Los Angeles.

The country rock here is granitic and in the vicinity of the deposit appears to be largely pegmatite. The deposit is a segregation in this rock. The strike is not apparent, although a series of trenches, each exposing the feldspar, suggests that it is northeast. By means of these trenches it has been traced on the surface some 300 feet. In every case, there is from one to nearly 3 feet of quartz overburden. The full width has not been exposed in spite of the fact that the present working pit has cut across it for 60 feet or more.

Development work, other than the shallow trenches mentioned above, consists of an open pit 60 feet to 70 feet long, 20 feet wide and 20 feet deep at the southeast end. This whole mass was feldspar and the sides and face are wholly in the same material. The only impurities consist of an occasional stringer of vermiculite from 1 to 3 inches in width or some of the quartz overburden loosened by blasting. Immediately south of and adjoining the deep pit is the shovel pit some 50 feet wide, 70 feet long, and 5 feet deep. The power shovel loads into 10-ton trucks which haul about 160 miles to the company's plants.

This appears to be a tremendous deposit, but in its present state of development no intelligent estimate of the tonnage could be made.

One man mines and loads the material, shipping from 60 to 100 tons per week. Shipments to date have aggregated about 15,000 tons.

Fluorspar

Fluorspar, or calcium fluoride (CaF_2), is one of the most important nonmetallic minerals from an industrial standpoint. Its principal use is as a flux in the manufacture of steel; also used in aluminum smelting and in the manufacture of enamel ware, glazed tile, brick, opalescent glass and certain chemicals. Due to the increased steel production and the construction of aluminum plants on the West Coast, there is an increased demand for fluorspar. There are a number of small deposits of this important mineral in San Bernardino County but no commercial production has resulted. Deposits of fluorspar occur near Baxter and Afton canyons; also, east of Victorville and in the Silver Mountain district near Adelanto.

Afton Fluorspar Deposit. It is situated 3 miles southeast of Afton, a station on the Union Pacific Railroad, in Cave Canyon mining district, sec. 7, T. 10 N., R. 6 E., S. B.; elevation 2100 feet; owners, Essential Minerals Company, Fred T. Smith, president; Mark Cadwallader, consulting engineer, 617 Black Building, Los Angeles.

The deposit consists of a series of parallel veins which trend eastward, with varying dips. The veins are from a few inches to 2 feet in width. During 1918 several shipments were made from the property reported to assay 80 to 85 percent CaF_2, with a silica content of 5.40 percent. Developed by open cuts and trenches. Idle.

Bibl.: State Mineralogist's Reports XVII, p. 343; XXVII, pp. 375-376.

Green Hornet Fluorspar Deposit. It comprises 17 claims situated in secs. 7 and 8, T. 6 N., R. 1 W., 16 miles northeast of Lucerne P. O. and 30 miles by road northeast of Victorville; elevation 3500 feet; owner, Mrs. L. B. Garvell, 2580 Lincoln Boulevard, San Bernardino, California.

Five parallel quartz veins occur in granite, strike east, dip 80° S.; width 4 to 6 feet. The fluorite occurs in irregular lenses in the quartz veins. Development is confined to quartz veins about 40 feet apart. A shaft has been sunk on one of the parallel veins to a depth of 80 feet. On the 80-foot level a drift has been driven east 125 feet. About 100 feet east of shaft, a crosscut has been driven north to parallel vein a distance of 40 feet. In the east drift developed several small lenses of fluorspar about 10 feet in length. It is estimated that there is about 2000 tons of ore on the dump reported to carry 40 percent CaF_2. Ten tons of sorted ore is reported to carry 85 percent CaF_2, with 12 percent silica.

Equipment consists of 6-horsepower gasoline hoist and 70-cubic foot Ingersoll-Rand air compressor. Idle.

McKinney Fluorspar Deposit. It comprises 2 claims situated on a low range of hills a mile south of the Gold Belt mine, in sec. 1, T. 6 N., R. 1 W., S. B., 27 miles by road east of Victorville; owners, C. J. McKinney, F. C. Snyder, D. R. Brown, Victorville, California.

A quartz vein occurs in granite, strike east, dip vertical; width 6 feet. A 6-inch streak of purple and green fluorspar occurs on one wall of the vein, then 4 feet of quartz mixed with fluorspar. About a quarter of a mile south is a parallel vein of quartz mineralized with fluorspar. Development consists of a shaft 10 feet in depth. About 50 feet east of this shaft, an incline shaft has been sunk on the vein to a depth of 55 feet. Idle.

Primer Fluorspar Deposit. It comprises 3 claims on the northeast slope of Shadow Mountain in the Silver Mountain mining district, 8 miles northwest of Adelanto, in sec. 20 (?), T. 7 N., R. 6 W., S. B.; elevation 3000 feet; owner, George B. Primer, Lancaster, California. Irregular bunches and stringers of fluorspar occur along a fissure in limestone. The fissure strikes N. 20° E., dips 60° W.; width 4 feet. A shaft is sunk on fissure to a depth of 15 feet and there are also some shallow open cuts along the fissure north and south of shaft. From high-grade bunches of fluorspar, samples are reported to carry 85 per cent CaF_2, and 4 percent silica. Idle.

Granite

Texas Quarries Granite Deposit. The property comprises 160 acres situated in sec. 29, T. 5 N., R. 2 E., S. B., 35 miles east of Victorville and 8 miles east of Lucerne; elevation 3700 feet; owner, Texas Quarries, Inc., Austin, Texas; W. H. Johnson, president; C. H. Owens, vice president and manager; J. J. Kell, superintendent.

A massive outcrop of granodiorite occurs in a series of granite hills that strike north. The color of the granite is pearl white to oxford gray; the granite is of very fine texture and hardness. The quarry is 200 feet in length, 100 feet in width, and 10 to 20 feet in depth.

Equipment consists of 30-ton Insley steel derrick, with 100-foot boom; a 125-horsepower caterpillar, diesel engine drives winch; also 300-cubic foot Ingersoll-Rand compressor. Any size granite blocks desired can be quarried. The granite is hauled by trucks to finishing plant at Victorville.

Equipment at yards at Victorville consists of 30-ton steel derrick, with 80-foot boom; polishing machines; 2 wire-cutting machines; 3 finishing machines and 150-cu. ft. compressor.

The finished product shipped is known as Lucerne Golden Vein Granite, Lucerne Oxford Granite, Lucerne Pearl White Granite. The deposit was operated during 1940 and 1941. It closed down the latter part of 1942 on account of conditions due to World War II. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 82.

Gypsum

Deposits of gypsum occur in the desert region of San Bernardino County but there has been no production in recent years. Gypsum occurs loosely cemented with sand in coarse crystals in Bristol Lake near Amboy. A similar deposit occurs at Danby Dry Lake. Gypsum also occurs in thin-bedded deposits in the Avawatz Mountains and to a lesser extent in the borax beds of the Calico district.

Bibl.: State Mineralogist's Reports XV, pp. 868-870; XVII, pp. 351-352; XVIII, p. 232; XXVII, p. 382; Bull. 38, 67, 91; U. S. Geol. Survey Bull. 223, 413, 430, 697; U. S. Bur. Standards, Circular N. 281.

Avawatz Gypsum Deposits. The deposits comprise twenty 160-acre placer claims situated on the northeast slope of the Avawatz Mountains, in secs. 13, 16, 21, 22, 27, 36, T. 18 N., R. 5 E., S. B., 20 miles northwest of Riggs, a station on the Tonopah & Tidewater Railroad and 50 miles north of Dunn Siding, on the Union Pacific Railroad; elevation 1000 to 1500 feet; owners, Avawatz Salt & Gypsum Company, H. H. Kerckhoff, Jr., president and manager, 2545 Raleigh Drive, San Marino, California.

Extensive deposits of gypsum occur in the lower lake beds, in Salt Basin, Big Gypsum Hill and West End. The gypsum veins are from 100 to 300 feet in thickness. The gypsum occurs as pure, crystalline gypsum and where exposed in different workings, is estimated to reach 4,000,000 to 10,000,000 tons. Analysis is stated to show 94 percent gypsum.

The principal development has been done on the West End gypsum deposit, which is located on two 160-acre placer claims and one 40-acre placer. Here, the gypsum beds strike N. 20° W., dip 20° W., and can be followed along the strike of the beds for 1 mile. The estimated thickness of the beds is 100 feet. Development consists of open cuts and short tunnels. On Big Gypsum Hill deposit which is located north of Demming Springs Wash, is an extensive deposit of gypsum over a mile in length and the beds are 200 to 500 feet thick. Beds strike northwest, dip 40° NE. Development consists of tunnels and open cuts. One tunnel is driven 50 feet in length on top of ridge and the other tunnel is driven southwest 50 feet.

In Salt Basin to the southwest of the main camp are extensive beds of gypsum. A crosscut tunnel, driven south 200 feet in the beds of gypsum develops gypsum intermixed with clay shales. These deposits of gypsum have commercial possibilities but have not been productive due to distance from railroad transportation.

Bibl.: State Mineralogist's Reports XVII, p. 352; XVIII, p. 232; XXVII, p. 382.

Couchman Gypsum Deposit. It comprises 160 acres in T. 18 N., R. 10 E., situated at Coyote Holes, 12 miles northeast of Valjean, a station on the Tonopah & Tidewater Railroad. Analysis shows 94 percent gypsum. The beds have a thickness of 200 feet. Undeveloped.

Bibl.: State Mineralogist's Report XXVII, p. 382.

Limestone, Cement, Marble, and Dolomite

Adelanto Limestone Deposit. It comprises 320 acres, patented, situated in the Silver Mountain mining district, on the southeast slope of Shadow Mountains, in sec. 2, T. 6 N., R. 6 W., S. B., 4½ miles northwest of Victorville; elevation 3000 feet; owners, J. H. Whitlock and D. H. Fry, 1502 Wayne Avenue, South Pasadena, Cailfornia.

The ridge is made up of blue-gray crystalline, fine-grained limestone. The general strike of the limestone beds is N. 20° W. and can be followed across the Black Marble placer and Dee placer claims for a distance of half a mile. The beds have a thickness of over 1000 feet and are exposed above the desert plain for an altitude of over 400 feet. Development consists of a quarry face 1500 feet in length. Estimated tonnage is 50,000,000 tons.

Analysis: Smith-Emery Company

Silica (SiO_2)	3.36%
Iron and alumina (Fe_2O_3 and Al_2O_3)	0.74%
Calcium oxide (CaO)	52.50%
Magnesium oxide (MgO)	0.36%
Ignition loss	41.52%
Calcium carbonate ($CaCo_3$)	94.0 %

Arlington Mining Corporation has deposits[12] of limestone in Blackhawk Canyon, on the northeast slope of the San Bernardino Mountains, largely in T. 3 N., R. 2 E., S. B., about 25 miles southeast of Victorville; elevation from 4200 to 6700 feet; owner, James Hay, Los Angeles.

Sections shown in the paper by Woodford and Harriss[12] indicate thicknesses of limestone up to 700 feet.

Baker limestone deposit comprises 160 acres in sec. 26(?), T. 14 N., R. 8 E., S. B., 1 mile west of Baker; owner, J. W. Neblett, Riverside, California. This deposit forms a rounded hill which rises 400 feet and is 2 miles in length along its north-south axis. The limestone is crystalline, blue to gray in color and is approximately 98 percent calcium carbonate.

Baxter and Ballardie quarry is in sec. 12, T. 11 N., R. 6 E., S. B., near Baxter, a station on the Union Pacific Railroad; owner, Mrs. Louis D. Rasor, Los Angeles, California. Railroad facilities for loading material are now within a few hundred feet of the quarry face.

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[12] For description of these deposits, see: Woodford, A. O., and Harriss, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, California: California Univ., Dept. Geol. Sci., Bull. 17, pp. 265-304, 1928.

For description of the deposit see State Mineralogist's Report XV, pp. 872-876.

Cajon limestone deposit consisting of 420 acres is in Lone Pine Canyon, secs. 27 and 32, T. 3 N., R. 6 W., S. B., 4 miles west of Cajon, a station on the Santa Fe Railroad; elevation 3000 to 5000 feet; owner, Mrs. Lorin O. Forman.

This belt of crystalline limestone, strike northwest, occurs in pre-Cambrian gneiss and schist. It is about half a mile in width and is traceable for several miles. Three quarries have been opened on the north side of the road from Cajon to the Los Angeles County Playground.

A plant was constructed in Cajon Canyon consisting of a rotary kiln having a capacity of 125 tons per day. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 383.

California Portland Cement Company, E. E. Duque, president; L. E. Bancroft, secretary; W. C. Hanna, chief chemist and mechanical engineer; E. I. Hendrickson, superintendent, 601 West Fifth Street, Los Angeles, owns and operates the Colton Cement plant and quarry, situated in secs. 19 and 30, T. 1 S., R. 4 W., about a mile west of Colton.

The plant is at the foot of the south slope of Slover Mountain and the quarry is in the south side of this mountain which is approximately a mile long, half a mile wide at its base, and 500 feet high. With the exception of a little shale, the whole mass is crystalline limestone suitable for the manufacture of cement. The shale is not waste as it also is utilized in the mix. The present quarry face is about 3500 feet long and something over 300 feet in height. The rock is broken by churn drill holes from the top and coyote holes in the face. One such shot a few years ago brought down more than a million tons.

The rock is loaded into 30-ton trucks by two 3½-yard electric shovels and hauled to a 66-inch by 84-inch jaw crusher the feed floor of which is on the quarry floor. The 10-inch product goes to No. 9 gyratory, then No. 18 gyratory, by means of elevators, to vibrating screen; plus ¾-inch to hammer mill, discharge from which together with undersize from screen go to storage bins, thence to driers to twelve 250-ton proportioning bins, where it is held until analyses of samples show that the proper mix has been attained. From bins to battery of 6-foot by 22-foot tube mills, one 7½-foot by 26-foot tube mill and Allis-Chalmers preliminator mill, where it is all ground to minus 200 mesh. These machines are equipped with air separators. From raw grinding section to silos having storage capacity of 16,000 tons, thence by Fuller-Kenyon pumps to 8 kilns, seven 200 feet in length, one 236 feet long, thence to cooling rotary tubes to belt to clinker pile, where gypsum is added, reclaimed by traveling crane and the grinding is finished by tube mills. The plant has a capacity of 50,000 sacks of cement per day, being the largest in the West. The company has been making cement on practically this same site since 1891. Two hundred and fifty men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 857-858; XVII, pp. 335-336; XXVII, p. 384.

Chalmers Dolomite Deposit. It comprises 640 acres of patented land situated in Bristol Mountains, in sec. 29, T. 6 N., R. 13 E., S. B., 6 miles east of Amboy; owner, A. F. Becker, 4278 Beverly Boulevard, Los Angeles.

The deposit of dolomite occurs as a series of low hills that rise above the floor of the desert plain from 100 to 400 feet in height. Estimated tonnage is 1,000,000 tons of commercial dolomite.

Analysis by Smith-Emery Company, Los Angeles

Acid insol.	1.00%
Alumina (Al_2O_3)	0.36%
Iron (Fe_2O_3)	0.20%
Calcium oxide (CaO)	33.68%
Magnesium oxide	18.23%
Loss in ignition	46.50%
Calcium carbonate	60.10%
Magnesium carbonate	38.12%

Chubbuck limestone and dolomite deposits are in sec. 17, T. 6 N., R. 14 E. and secs. 20 and 21, T. 6 N., R. 14 E., respectively. The deposits are on the south slope of the Marble Mountains about 6 miles northwest of Cadiz, a station on the Santa Fe Railroad and some 4 miles north of Highway 66; owner, Chubbuck Lime Company, C. I. Chubbuck, president, 5000 Worth Street, Los Angeles; under lease and option to the Kaiser Company, Inc., Fontana, California.

The deposit strikes east. Its outcrop is 4000 feet long. On its east end it is 250 feet wide and is reported to be 200 feet wide at its west end and is 750 feet thick. On its north and west sides it is in contact with rhyolite while on the south it is against the dolomite. It is a fine-grained, compact, white limestone.

Analyses of samples from southwest face gave:

	Sample A	*Sample B*
Lime (CaO)	54.8%	55.5%
Silica (SiO_2)	1.7%	0.5%
Magnesia (MgO)	0.4%	0.08%
Iron (Fe)	0.15%	-----
Alumina (Al_2O_3)	---	0.28%
Iron (Fe_2O_3)	---	0.02%
Ignition loss	---	43.61%

Tonnage of commercial limestone in the deposit has been estimated at 100,000,000.

The dolomite parallels the limestone forming its south boundary.

Analyses of samples from the deposit gave:

	Sample No. 1	*Sample No. 2*
Lime (CaO)	31.04%	31.00%
Magnesia (MgO)	20.20%	21.10%
Silica (SiO_2)	0.60%	0.40%
Iron and alumina	0.45%	0.50%

The Kaiser Company, Inc., has opened a quarry in this material which is now 50 feet long 25 feet wide and 50 feet high. The dolomite is shipped to their steel plant for test purposes to determine if it is suitable for use in open hearth furnaces.

The material is hauled by truck 7 miles to Cadiz for rail shipment. Six men are employed on this operation.

Chubbuck Lime Company's Limestone Deposits. The property comprises 3 patented placer mining claims known as Lime Quarry No. 1, Lime Quarry No. 2 and Lime Quarry No. 3, each claim containing 160 acres, in secs. 10, 11, 15 and 22, T. 3 N., R. 16 E., S. B., and 480 acres in sec. 16 and all of sec. 21, T. 3 N., R. 16 E., S. B., situated on the north end of Iron Mountains at Chubbuck, a station on the Santa Fe Railroad. Total holdings are 1600 acres. Elevation is 1000 to 1500 feet; owner, Chubbuck Lime Company, C. I. Chubbuck, president and manager; Lt. Col. Dixon Chubbuck, vice president; Mrs. A. S. Chubbuck, secretary; E. L. Anderson, treasurer; E. H. McEwen, supervising engineer; Oscar B. Myers, sales manager, San Francisco; Vernon R. Dick, superintendent, Chubbuck, California. Offices are located at 5000 Worth Street, Los Angeles.

The property has been under production since 1925. The limestone is being quarried from High Lime Ridge located on Lime Quarry No. 2 placer mining claim. The High Limestone Ridge has a general northeast course. The beds of limestone strike N. 30° W., dip 30° to 40° SW. The ridge is 1½ miles in length and about a mile wide, and rises above the floor of the desert plain to an altitude of 500 feet. There are also three limestone ridges roughly parallel to High Limestone Ridge which have the same general strike and are about a quarter of a mile wide. Southwest of these limestone ridges is a ridge of dolomite which is 1 mile in length and half a mile wide and about 400 feet in elevation above the floor of the desert plain. These deposits are in sec. 16. The main quarry is on High Lime Ridge and is in the S½ sec. 15. Limestone has been quarried from four quarries known as No. 1, No. 2, No. 3, and No. 4. No. 4 quarry is 500 feet in length by 200 feet in width by 30 feet high; No. 3 quarry is 600 feet in length by 150 feet in width and 30 feet high; No. 2 quarry is 500 feet long by 150 feet wide by 30 feet high.

The limestone is being quarried from No. 4 quarry. The broken material is loaded by gas-driven shovel ⅜-yard bucket, into 5-ton dump truck and hauled to ore bin with a capacity of 150 tons. Material is dumped onto railroad iron grizzly spaced to 8 inches; rock from bin loaded into side-dump cars, capacity 2½ tons per car; hauled in train of 5 cars by Plymouth gas-driven motor to crushing plant where dumped into ore bin; from bin to Kennedy gyratory crusher, crushed to 1½-inch size; crushed rock elevated by bucket elevator to top of screening plant equipped with 5 Cottrell shaking screens, making the following products: 1½-inch, 5/16-inch, ⅛-inch, 16 mesh and 40 mesh. These products go to separate bins, above concrete tunnel, there being 4 bins on one side and 2 bins on the other side. The sized products from bins are loaded into steel side-dump cars and hauled over narrow gauge railroad in trains of 4 to 6 cars, capacity 2½ tons of rock per car, by Milwaukee gas-driven locomotive to plant at Chubbuck, a distance of 1 mile. The 5/16-inch to 1½-inch product to lime kiln plant. The other sizes are hauled by train to trestle to elevator and shipped.

The 5/16-inch to ⅛-inch products are ground in pebble mill, then to air separator and the 80 mesh and 200 mesh products are sacked for shipment to Los Angeles and San Francisco.

The crushing and screening plant is driven by one 1-cylinder, 50-horsepower Fairbanks-Morse semi-diesel engine and one 35-horsepower semi-diesel Fairbanks-Morse engine drives Sullivan compressor for operation of air drills at quarries. The crushing and screening plant has a capacity of 20 tons per 8-hour shift.

Lime kiln plant: The 5/16-inch to 1½-inch product from screening plant is hauled by ore train over narrow gauge railroad to hopper to 24-inch belt conveyor to 50-ton storage bin. From bin it is elevated

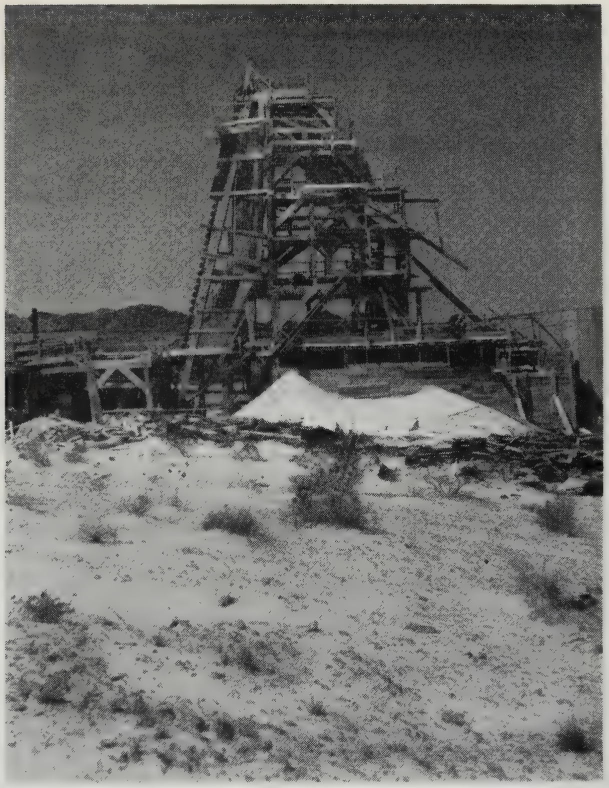

FIG. 16. Chubbuck Lime Company's crushing and screening plant, Chubbuck.

by bucket elevator to circular steel storage bin, capacity 50 tons. From steel storage bin, material is fed by automatic feeder to rotary kiln (50 feet in length by 5 feet in diameter); heated to 2000° F.; the calcined lime from kiln to steel hopper; elevated by bucket elevator to revolving screen and screened to $\frac{1}{4}$-inch size. The minus $\frac{1}{4}$-inch size produced to circular steel bin, capacity 40 tons; the plus $\frac{1}{4}$-inch material to 3 circular steel ore bins, each having a capacity of 40 tons. From the three bins, the lime is drawn by screw conveyor to 20-ton capacity bin, then by automatic feeder to 14-foot by 5-foot pebble mill, driven by 75-horsepower motor. The product from pebble mill then goes to elevator to separator; the oversize returned to pebble mill. The calcined lime is ground to minus 200 mesh for processed lime. The 200 mesh product is elevated to storage bin from which it goes to bag packing machines and is sacked for shipment. The oversize lime products are fines and pebble lime.

Limestone products plant: The $\frac{5}{16}$-inch and $\frac{1}{8}$-inch product to 5 feet in diameter by 14 feet long pebble mill, driven by 60 horsepower motor; the ground product from pebble mill to separator; two products produced are 80 mesh and minus 200 mesh; the oversize from separator returned to ball mill.

Power plant at Chubbuck for operating kiln and pebble mills consists of one 120-horsepower, 4-cylinder, Fairbanks-Morse full diesel engine, direct connected with 75 K.V.A. generator and one 110-horsepower Fairbanks-Morse, 2-cylinder, diesel engine, direct connected with 75-horsepower K.V.A. generator and one 60-horsepower horizontal Fairbanks-Morse full diesel engine. The 110-horsepower diesel engine operates kiln, screen, and pebble mill. When both pebble mills are under operation, the 120-horsepower diesel engine is operated. Water for camp and plant is secured in tank cars from the Santa Fe Railroad Company's wells at Cadiz.

The lime products produced are processed lime and pebble lime. Limestone products are 40 mesh limestone, 80 mesh limestone, 200 mesh for whiting, chicken grits and foundry rock 1½-inch to 2½-inch sizes.

Analysis of crude limestone

Silica (SiO_2)	0.20%
Alumina (Al_2O_3)	0.30%
Calcium oxide (CaO)	56.00%
Magnesium oxide (MgO)	none
Loss in ignition	43.30%
Calcium carbonate	99.80%

Twenty-four men are employed at quarry and plant.

Cima Limestone Deposit. It is situated in secs. 12, 13, and 24, T. 15 N., R. 13 E. and in sec. 7, T. 15 N., R. 14 E., S. B., about 10 miles northeast of Cima, a station on the Union Pacific Railroad. The holdings comprise 1400 acres; elevation 4900 to 5900 feet. Owners are James Vernon, Arlington, California, R. F. Slaughter, Riverside, California, and associates.

The deposit constitutes the main portion of the westerly spur of Ivanpah Mountains. Analysis of samples taken reported 97.20 percent $CaCO_3$, 0.45 percent MgO, and 1.09 percent SiO_2. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 384-385.

Devils Canyon Limestone Deposit. It comprises 320 acres situated in Devils Canyon in the San Bernardino Mountains in the N½ sec. 5, T. 1 N., R. 4 W., S. B., 6½ miles north of San Bernardino; elevation 1500 feet; owner, San Bernardino Limestone Company, Inc., Julian Bailey, president and manager; Cresti Waldenfelds, secretary, 1709 West Eighth Street, Los Angeles.

A wide belt of white, crystalline limestone 98.8 percent $CaCO_3$ occurs on this property. The material is quarried and then goes to crushing and screening plant with a capacity of 40 tons per day. The screened material is shipped to Western Milling & Manufacturing Company of Los Angeles for use in defense housing projects. Six men are employed.

Hesperia Dolomite Deposit. It comprises five 160-acre placer claims, located on the north slope of Ord Mountain in secs. 27, 28, 33, T. 4 N., R. 3 W., S. B., 7 miles east of Hesperia, a station on the Santa Fe Railroad; elevation 3500 to 4200 feet; owners, S. D. Greenwood, Clinton Ray and Claire Dunton, Glendale, California.

The deposit of dolomite is 700 feet thick by half a mile in width and 1½ miles in length. The dolomite is white to brown in color.

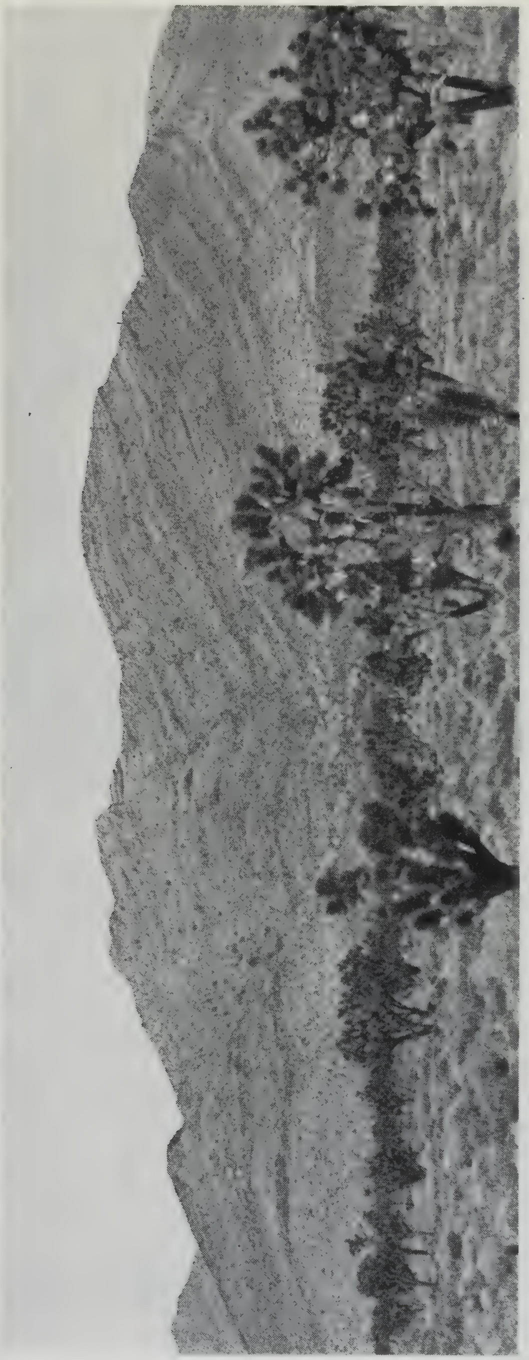

FIG. 17. Cima limestone. *Photo courtesy of James Vernon.*

Analysis

Calcium oxide (CaO)	32.1 %
Magnesium oxide (MgO)	21.7 %
Silica (SiO_2)	0.40%
Iron (Fe_2O_3)	0.40%

The estimated tonnage is said to be 80,000,000. Idle.

Hinkley dolomite deposit comprises 320 acres in the SE¼ sec. 11 and the SW¼ sec. 12, T. 9 N., R. 4 W., 4 miles southwest of Hinkley, a station on the Santa Fe Railroad. The owner is A. R. Mills, 9396 Second Street, Riverside, California; under lease to W. C. O'Connor, 7940 Sunset Boulevard, Los Angeles; J. A. Vandergrift, consulting engineer.

The deposit forms a ridge, the axis of which trends east. On the north this ridge rises abruptly to some 200 feet above the valley, while the south slope is much more gradual. On the north, the granitic rock which apparently forms the footwall of the deposit outcrops to about 50 feet above the valley, while on the south the deposit dips under the alluvium of the valley. The deposit is approximately 200 feet long by 1200 to 1500 feet wide, at the base of the ridge, by 150 feet high. Except for a few narrow, discontinuous diorite dikes which strike N. 50°-60° E., the whole mass is white to light-gray dolomite, the analysis of which is as follows:

Analysis

Silica (SiO_2)	3.03%
Alumina (Al_2O_3)	0.25%
Iron (Fe_2O_3)	trace
Lime (CaO)	28.93%
Magnesia (MgO)	20.93%
Ignition loss	48.86%

Some 4 miles of road has been built from the Hinkley highway to the deposit. At the terminus of this road, which is about midway between the east and west extremities of the deposit, and 125 feet below the crest of the ridge on the south slope, the following plant is nearing completion:

Railroad rail grizzly, about 15-inch openings, to pocket to inclined 20-inch belt conveyor to 12-inch by 24-inch jaw crusher to 18-inch inclined conveyor to hopper to double deck vibrating screen; ⅝-inch and ⅛-inch, plus ⅝ by elevator to Symons Impact crusher back to screens; the minus ⅝-inch plus ⅛-inch by two inclined, 18-inch conveyors to 3 bins each 130 tons capacity. The plant is all steel construction. Machines have individual motor drives. Power is supplied by 3-cylinder, Fairbanks-Morse, diesel engine, direct-connected to 162 k.v.a. generator. There is also a 309-cu. ft. Chicago pneumatic compressor to supply air for the quarry.

The plant has a capacity of 50 tons per hour. The product will be shipped to Kaiser Company's steel mills at Fontana.

Seven men are working on construction.

Jack Frost deposit, consisting of 160 acres, is in the Bristol Mountains, 6½ miles northeast of Amboy, a station on the Santa Fe Railroad, in sec. 26, T. 6 N., R. 12 E., S. B.; owners, D. N. Smith and associates, of Los Angeles.

This deposit of crystalline limestone is approximately 3000 feet long, 1200 feet wide, and 400 feet thick. The strike is northwest, the dip 30°

to 40° NE. It has been intruded by a series of diorite and andesitic dikes; strike N. 30° W., dip 60° to 70° NE. Idle.

A. B. McAntire, 7721 South Main Street, Los Angeles, and Elmo Proctor, Yermo, California, own a marble deposit in the Mojave Sink country. It is 4½ miles east of Soda and 10 miles south of Baker.

Bibl.: State Mineralogist's Report XXVII, p. 386.

O'Connell Deposit is 3 miles southeast of Ivanpah, a station on the Union Pacific Railroad, in secs. 8, 9, T. 14 N., R. 16 E., S. B.

Bibl.: State Mineralogist's Report XXVII, 386.

Richter Dolomite Deposit. The property comprises 2 placer claims and 2 lode claims located on a low hill in north Lucerne Valley, in SE¼ SE¼ sec. 15, T. 6 N., R. 1 W., 10 miles north of Lucerne P. O. and 30 miles northeast of Thorn Siding, on the Santa Fe Railroad; elevation 3300 feet; owner, Marter Mining Company, R. M. Richter, president and manager; Lawrence B. Martin, secretary, 530 West Sixth Street, Los Angeles.

The general strike of the dolomitic limestone beds is N. 20° W., dip 70° E. On the north slope of the hill the dolomite beds are cut by a granite intrusive dike, strike N. 50° E., dip 45° NW. The dolomitic beds are also cut by a network of stringers and veins of magnesite, with widths varying from 2 inches to 18 inches. One series of magnesite veins strikes east; the other series strikes north. Development consists of a number of open cuts and shallow shafts from 10 to 20 feet in depth. It is estimated the deposit contains 1,200,000 tons of commercial dolomite. The crystalline dolomite is white to brown in color, fine to medium grain.

Analysis by Smith-Emery Company of dolomite:

Silica (SiO_2)	0.46%
Aluminum oxide (Al_2O_3)	1.05%
Iron oxide (Fe_2O_3)	0.09%
Calcium oxide (CaO)	34.64%
Magnesium oxide (MgO)	23.97%
Carbon dioxide (CO_2)	29.40%
Moisture and combined water	9.97%
Total	99.54%

Two men are employed on development work.

Riverside Cement Company's Oro Grande Quarry and Plant (formerly known as Golden State Portland Cement Co.). (Secs. 9, 16, and 17, T. 6 N., R. 4 W., S. B.) Owner, Riverside Cement Company, G. A. Beckett, president; W. H. Leonard, general manager, 621 South Hope Street, Los Angeles. The plant is located at the northeast end of the town of Oro Grande and the quarry is about 2 miles east of the plant. The quarrying and hauling to the plant is done under contract by A. S. Vinnell & Company, 1145 Westminster Avenue, Alhambra, California.

The present quarry which was started at the time the plant recently resumed operations, is a side-hill cut about 350 feet long, 300 feet wide, with an average height of 50 feet. The limestone averages 94 to 95 percent $CaCO_3$ and is low in magnesia. Near the center of the quarry is a 20-foot vein of iron ore which is utilized in the mix.

Wagon drills and jackhammers are used to drill the face. A 2½-yard Northwest shovel loads the broken rock into five 10-ton trucks. Equipment consists of Gardner-Denver 350-cubic foot direct-connected, diesel-driven compressor and one D-8 caterpillar with blades. From 1000 to

1100 tons per day are shipped. Eighteen to 20 men are employed for this operation.

Cement Plant: Trucks dump into 3-foot Mammoth-McCully gyratory crusher to inclined conveyor to bin, rotary feeder to 5½-foot Symons cone crusher; elevator conveyor to stock pile; reclaimed by 30-inch belt conveyor in tunnel; elevator to conical bottom, steel bin to Bradley roll crusher; screw conveyor to elevator to bin; screw conveyor to feed bins for raw grinders, consisting of six 6-foot by 16-foot and one 6-foot by 24-foot tube mills. These mills discharge to conveyor to elevator to 3 raw silos, thence to 2 cross conveyors, elevator to conveyor to 5 kiln feed bins. Kilns discharge to steel drag conveyor to McCausland bucket elevator to clinker stock pile; reclaimed by Colby crane, loaded to railroad cars and shipped to the company's Crestmore plant for finishing. Capacity as now run, about 3000 barrels per day. About 70 men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 858-859; XVII, p. 336; XXVII, p. 385.

Silver Dome deposit is in sec. 9, T. 32 S., R. 42 E., M. D., 20 miles southeast of Randsburg.

Bibl.: State Mineralogist's Report XXVII, pp. 387-388.

Silver Lake deposit covers 120 acres, 3 miles west of Silver Lake, a station on the Tonopah & Tidewater Railroad, in secs. 18, 19, T. 15 N., R. 8 E., S. B. The deposit has no overburden and analyses show it to be 99.8 percent calcium carbonate.

Snowcap limestone deposit comprising 160 acres on the southeast slope of the Bristol Mountains, is 6 miles northeast of Amboy, a station on the Santa Fe Railroad, in sec. 30, T. 6 N., R. 13 E., S. B.; owners, Robert Allison, Frank L. Furlow, 1755 Griffith Park Avenue, Los Angeles, and associates.

This deposit is easily accessible from Amboy over a good road with no grades. It is approximately 700 feet thick by 1500 feet long and is reported to be 98.6 percent calcium carbonate.

Snow White marble deposit is in the New York Mountains, 4 miles southwest of the town of Barnwell, in sec. 20, T. 14 N., R. 16 E., S. B.

Bibl.: State Mineralogist's Report XXVII, p. 388.

Southwestern Portland Cement Company's Quarries and Plant. This company owns and operates three cement plants in the United States. Holdings of the company are located in secs. 11, 15, and 16, T. 6 N., R. 4 W., S. B., and secs. 5 and 6, T. 6 N., R. 2 W., S. B. Owner is Southwestern Portland Cement Company, Frank H. Powell, president; M. A. Koffman, secretary; C. C. Merrill, general manager; O. C. Halstead, superintendent; R. M. Wilson, chief chemist, 727 West Seventh street, Los Angeles.

Their California plant is at Victorville, the main quarry is about 6 miles northeast of the plant and the Reserve quarry is 14 miles east. The principal source of limestone is a deposit which strikes east, dip about 40° N. It has been opened by ten quarry faces in a length of about 2 miles. A standard gauge railroad connects these quarries with the plant. By opening the deposit in several different places they are able to secure the mix desired for any one of the several types of cement made and avoid the mining of waste. The material is loaded into 10-ton trucks by three 2-yard shovels. At each face the trucks dump directly into railroad cars on the quarry floor.

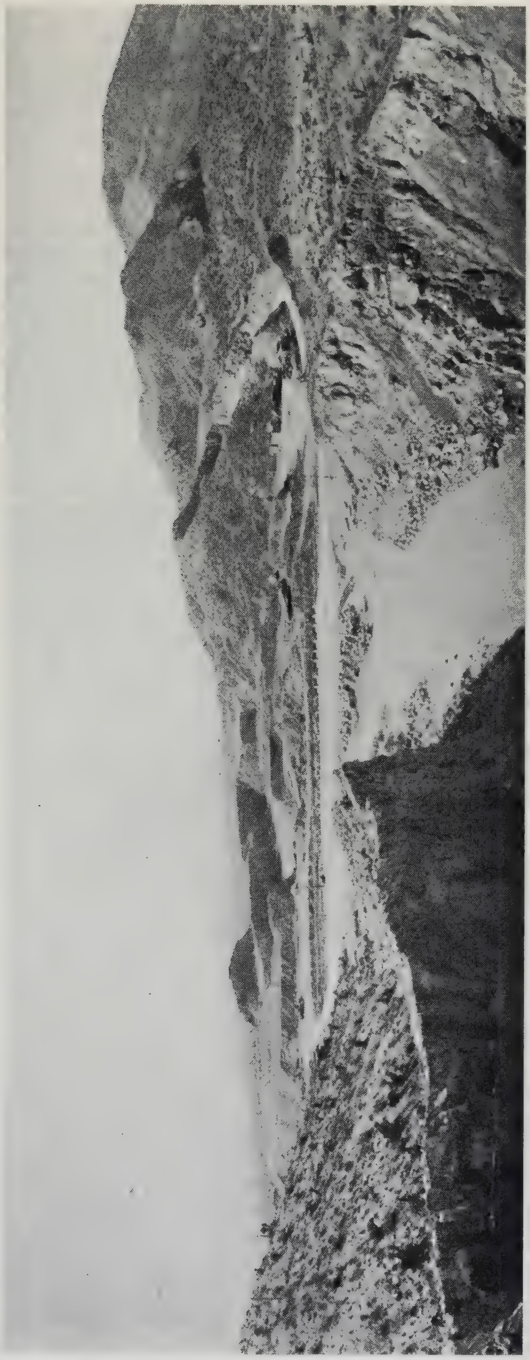

FIG. 18. Southwestern Portland Cement Company's limestone quarries, Victorville. *Photo courtesy of R. M. Wilson.*

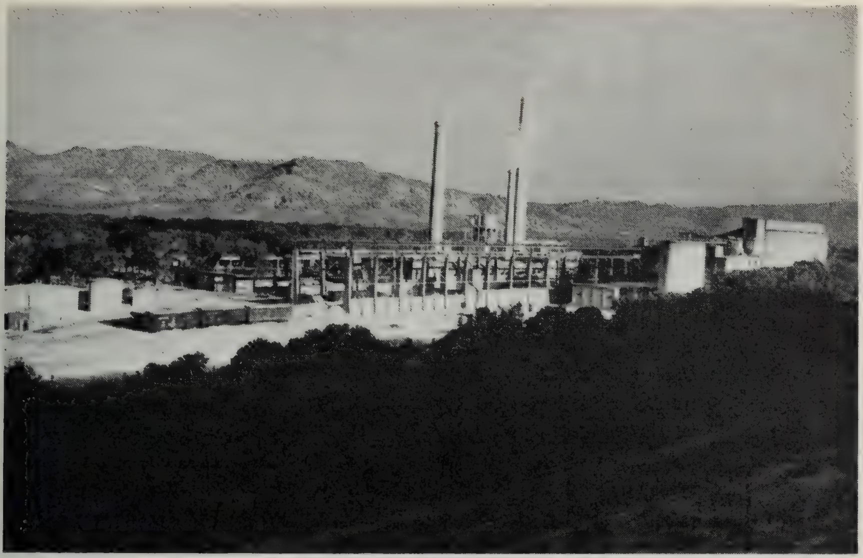

FIG. 19. Plant of Southwestern Portland Cement Company, Victorville. *Photo by Walter W. Bradley.*

The materials from these quarries are mixed with a limited tonnage from the Reserve quarry which is 10½ miles east. An excellent oiled road has been built from the rail loading point to the Reserve quarry, a distance of 10½ miles. This is a tremendous deposit of high-grade crystalline limestone which forms two hills that rise above the floor of the valley about 750 feet. The strike is northwest, dip to the northeast. The larger of these two hills is a dark but high-grade limestone; the other is white with just a few streaks of gray in it. Its length is approximately 4000 feet. In the white limestone there is an intrusion (diorite?) from about 25 feet to 50 feet wide in the shape of the letter ''K.'' This is the only foreign matter present and it will be utilized in the mix.

The white limestone has been developed by a quarry which is now about 700 feet long by 130 feet high. The face is drilled with churn drills. The material is loaded by 2½-yard diesel shovel into specially built trucks and trailers. Each unit (truck and trailer) carries 60 tons. This load is carried in six separate-dump steel bodies, three on the truck and three on the trailer, mounted at right angles to the chassis. At the end of the 10½-mile haul, the trucks dump directly into 30-ton railroad cars which complete the haul to the plant.

Cement Plant: Railroad cars dump directly into 48-inch by 72-inch jaw crusher, elevator to 10-inch cataract grizzly, oversize by pan conveyor to Williams mill to Pennsylvania hammer mill, elevator to Hummer screen, plus 1 inch by conveyor to stockpile, dust collected into bins. Stockpile reclaimed by two 20-inch conveyors in tunnels; elevator to grizzly, oversize to Kennedy gyratory, to 22-inch belt conveyor to raw grinding bins, mechanically fed to five wet, raw grinding tube mills, one 7 by 40 feet, and four 7 by 36 feet. Large mill has 3 and smaller ones 2 compartments; slurry from mills to Hummer screens, oversize back to mills, screenings by 3 Wilfley sand pumps to 16 blending tanks, thence by four 4-inch Wilfley sand pumps to two 80-foot Dorr thickeners in series where moisture is reduced from about 40 percent to approximately 31 percent, thence by four 3-inch Norris sand pumps to 5 kilns, each 200 feet long, clinker drops into revolving coolers, 8 feet by 96 feet at 2200°, discharged to torpedo conveyors at 250° to elevator to concrete clinker bin, distributed by 10-ton traveling electric crane. Clinker bins have a capacity of 150,000 barrels, reclaimed by conveyor in tunnel underneath bins to elevator, over scales to 36-inch by 16-inch rolls to elevator to drag conveyor to finish grinding bins, to 5 Compeb mills, one 7 by 40 feet, two 7 by 26 feet, and two 7 by 22 feet; product to elevator to centrifugal air separator, oversize back to mills, finished product by Fuller-Kenyon pumps to silos having a capacity of 140,000 barrels. Power is supplied by Southern Sierras Power Company. Capacity is 7000 barrels per day. There are 250 employees, ten percent of whom are women.

Bibl.: State Mineralogist's Reports XV, pp. 859-860; XVII, p. 337; XXVII, pp. 388-389.

Standard Limestone Deposit. It is 2 miles northeast of Ivanpah, a station on the Union Pacific Railroad, in sec. 20 (?), T. 15 N., R. 16 E., S. B.

Bibl.: State Mineralogist's Report XXVII, p. 389.

Sugar Loaf Mountain Dolomite Deposit. It comprises 60 acres on the north slope of Sugar Loaf Mountain, in sec. 17, T. 1 N., R. 2 E., S. B., 6 miles southeast of Big Bear Lake P.O.; elevation 7000 feet; owner, Albert Rose, Big Bear Lake, California.

The belt of dolomite is 1000 feet in width, 3000 feet in length and over 600 feet in thickness.

Analysis by John Herman, Los Angeles

$MgCO_3$	41.7%
$CaCO_3$	53.6%
MgO	22.0%

Idle.

Three Colored marble quarry is in the unsurveyed portion of T. 7 N., R. 2 W., S. B., 22 miles south of Barstow.

Bibl.: State Mineralogist's Report XV, pp. 881-883.

Twin Buttes dolomite deposit, comprising 160 acres, is in the SW¼ sec. 9, T. 5 N., R. 15 E., S. B., 1½ miles southwest of Siam, a station on the Santa Fe Railroad; owner, Ira Judson Coe; under lease to C. I. Chubbuck, 5000 Worth street, Los Angeles.

The deposit occurs as two dark-colored buttes rising from the plain on the northwest side of the Ship Mountains. They are composed entirely of dark-gray dolomite. The major axis of the larger butte is N. 40° E., paralleling the Ship Mountains. The dip of the dolomite is 25° SE. and its length is 1500 feet, with an average width of 700 feet and a maximum height of 165 feet above the plain. The smaller butte lies 600 feet to the northeast, is 600 feet long and rises 125 feet above the plain. Estimated tonnage in the two buttes is 8,000,000.

Vaughan Marble Quarries. It comprises two deposits of marble known as Lower Quarry Marble Tract and the Upper Quarry Marble Tract situated on the southwest slope of the Marble Mountains. The

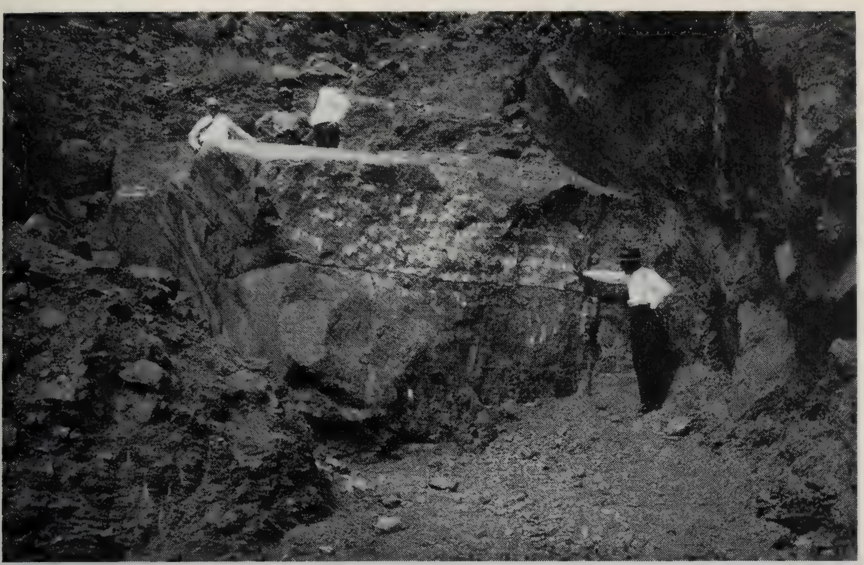

FIG. 20. .Lower Quarry, Calevanto marble; Vaughan Marble Company, Cadiz; 20-ton block of marble. *Photo by Arthur C. Vaughan.*

Lower Quarry Tract is in the NE. ¼ sec. 11, T. 5 N., R. 14 E. and the SE. ¼ sec. 2, T. 5 N., R. 14 E., S. B. and is 3½ miles southeast of Upper Quarry marble deposit and 2 miles north of Cadiz, a station on the Santa Fe Railroad; elevation 1500 feet. Upper Quarry Tract is situated on the west slope of Marble Mountains, in the NE. ¼ sec. 28, NW. ¼ sec. 27, and the SW. ¼ sec. 22, all of sec. 26, T. 6 N., R. 14 E., S. B., 5 miles north of Cadiz; elevation 1500 feet. Total holdings comprise 1440 acres, held by placer locations. Owner is Vaughan Marble Company, Arthur C. Vaughan, president, 437 South Hill Street, Los Angeles.

The Upper and Lower Quarry tracts are made up of sedimentary rocks of Cambrian age, consisting of quartzites, shales, and marbleized limestone. The beds strike N. 10° W., dip 35° E. Near the southern end of the Marble Mountains is a fault which strikes eastward, and south of this fault the beds strike N. 70° W., dip 55° N. The beds of marble have an average thickness of 20 feet. On the Lower Quarry Tract, two quarries have been opened from which blocks of marble weighing 15 to 20 tons were quarried. The marble is Calevanto, a highly colored, variegated marble. On the Upper Quarry Tract, the marble is fine-grained and beds are 10 feet thick and of uniform quality. The marble beds occur at an elevation of 650 feet above the floor of the valley and extend to the top of Marble Mountain. The marble belt is about 2 miles in length by 1 mile in width.

Three quarries have been opened on the west slope of Marble Mountain and a small amount of marble extracted. The marble exposed in these quarries is black and gold and black and silver, overlain by a blue-black monumental marble reported to be equal to Perwick marble of Wales; also some Egyptian pebble marble has been exposed. From a report made by G. M. Butler, E. M., Arizona School of Mines, the following analysis of marble and estimates were obtained:

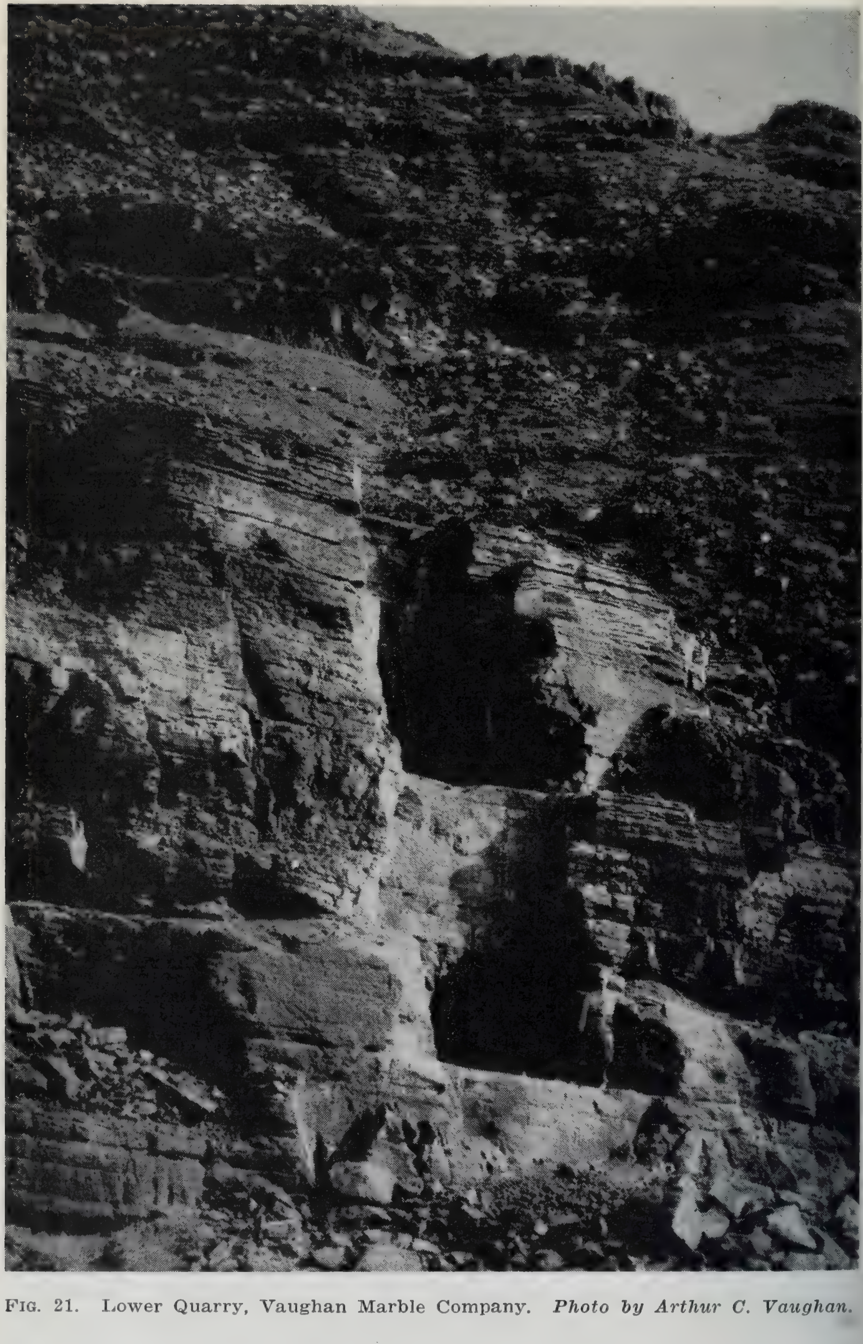

FIG. 21. Lower Quarry, Vaughan Marble Company. *Photo by Arthur C. Vaughan.*

Lower Quarry Tract—Old quarry:

Calcium oxide (CaO)	48.15%
Magnesium oxide (MgO)	2.48%
Silica (SiO_2)	4.64%
Iron (Fe_2O_3)	1.74%
Aluminum (Al_2O_3)	1.66%

Calcium carbonate 85.90%; magnesium carbonate 5.18%.

Butler estimated two million cubic feet of commercial marble could be quarried. Estimated yield of Lower Quarry Tract of 400,000 cubic feet, with an average thickness of 20 feet.

Upper Quarry Tract—Analysis:

Calcium oxide (CaO)	55.55%
Magnesium oxide (MgO)	3.04%
Silica (SiO_2)	1.98%
Iron (Fe_2O_3)	0.77%
Aluminum (Al_2O_3)	0.54%

Computed calcium carbonate 90.18%; magnesium carbonate 6.35%; estimated 5,000,000 cubic feet of commercial marble.

These marble deposits were discovered and worked in 1937. Two thousand cubic feet of Calevanto marble was quarried from Lower Marble Tract. The property was acquired by Vaughan Marble Company in July 1939 and operated until October 1939; about 2000 cubic feet of marble was quarried. The blocks of marble quarried were sold to Musto Keenan Marble Company, Los Angeles, and California Marble Company, Los Angeles. The blocks of marble were sawed, polished and placed in the following buildings: Gardena Post Office, Oxnard Post Office, Mullen & Bluett Store, Pasadena, Financial Center Building, Los Angeles, United States Mint, San Francisco, Custom House, San Francisco.

The variety and quality of the marble that can be produced from these deposits, also the possibility that large blocks can be quarried, would indicate that in the post-war period there should be a large demand for the marble. Idle.

Bibl.: Bull. 38, p. 102.

Verde Antique marble deposit is in sec. 28, T. 7 N., R. 2 W., S. B., about 24 miles south of Barstow.

Bibl.: State Mineralogist's Report XV, p. 883; Bull. 38, pp. 147-148.

Victorville Lime Rock Company, John S. Collbran, secretary, 5225 Wilshire Boulevard, Los Angeles, has leased from the Riverside Cement Company, 120 acres in the SW¼ sec. 25, T. 6 N., R. 4 W., and they own 570 acres in sec. 36, T. 6 N., R. 4 W., approximately 5 miles northeast of Victorville.

The present quarry faces are in sec. 25, on the southwest slope of a ridge, the axis of which is N. 20°-30° W. which apparently is also the strike of the limestone, the dip being to the southwest. This ridge, approximately 3000 feet long, rising about 200 feet above the floor of the valley, is limestone into which have been intruded numerous narrow diorite dikes. In some 1500 feet along the southwest slope six quarry faces have been opened. With one exception, these vary from small open cuts to faces 50 feet high by 100 feet in length. The exceptional quarry consists of a cut about 30 feet wide driven 250 feet into the side hill, at the end of which the face is some 75 feet in diameter, with a maximum height of approximately 70 feet. Present work is in the northernmost quarry, the face of which is about 60 feet long by 20 feet high.

The material is loaded in 5-ton trucks by a $\frac{3}{8}$-cubic yard diesel shovel and hauled to the plant at Victorville. A LeRoi portable compressor supplies air for jackhammers drilling the face. Five men are employed at the quarry.

The plant consists of 16-inch by 20-inch jaw crusher, elevator to bin to hammer mill, elevator to trommel with 20-16-4 mesh sections to vibrating screen 30(?) mesh. Dust from the various machines is collected in a cyclone and sacked; other products go from four bins direct to railroad cars by shuttle conveyor. Products are used for glass, chicken feed, stucco and lime. Capacity is about 50 tons in 14 hours.

Power is supplied by Southern Sierras Power Company. One man runs the plant.

Magnesite

Afton Magnesite Deposit. It comprises 3 claims situated in Cave Canyon mining district, on a steep hill on the east side of Cave Canyon, sec. 20, T. 11 N., R. 6 E., S. B., 1½ miles southeast of Afton, a station on the Union Pacific Railroad; elevation 1900 feet; owner, Cliffside Magnesite Company, W. J. Swan, secretary, San Bernardino, California.

The magnesite outcrops as a bold, white ledge, striking easterly over a ridge which rises abruptly out of the Mojave River bed to an elevation of 500 feet above the river. The vein of magnesite is 200 feet thick, strikes east, and dips 40° N. towards the river. The magnesite underlies a soft, red-colored, decomposed, conglomerate material. The magnesite varies in color from pinkish to white. Samples of magnesite show thin seams of silica. Idle.

Analysis of magnesite by Smith-Emery Company:

Silica (SiO_2)	10.10%
Aluminum (Al_2O_3)	1.73%
Iron (Fe_2O_3)	1.41%
Lime (CaO)	3.10%
Magnesium oxide (MgO)	38.19%
Carbon dioxide (CO_2)	40.65%

Bibl.: State Mineralogist's Reports XVII, pp. 353-354; XXVII, p. 390; Bull. No. 79, pp. 72-74.

Ball Magnesite Deposit. It comprises 4 claims known as Ball No. 1 to Ball No. 4, located 1 mile east of Sidewinder mine, in sec. 2, T. 6 N., R. 2 W., S. B., 4 miles southeast of Stoddard Well and 16 miles northeast of Victorville; elevation 3500 feet; owner, Red Seal Chemical Company, Inc., O. H. Ball, president, 2024 West 62nd Street, Los Angeles.

A series of parallel stringers and veins of magnesite occur along bedding planes in dolomitic limestone. The veins range in width from 2 inches to 2 feet. Veins strike north, dip 15° E. Development consists of three crosscut tunnels driven northwest, cutting different bedding planes. The tunnels are 15 to 25 feet in length. The magnesite developed is of very good quality but the veins being narrow, the tonnage developed is limited. Analysis by Smith-Emery Company of selected samples carried 47.6 percent MgO, with 52.4 percent CO_2, 2.4 percent SiO_2. Idle.

Kramer Hills Magnesite Deposit. It comprises one claim, known as Ball No. 2, situated on the southwest slope of Kramer Hills, in sec. 14, T. 9 N., R. 6 W., S. B., 9 miles southeast of Kramer, a station on the Santa Fe Railroad; elevation 3000 feet; owner, Red Seal Chemical Company, Inc., O. H. Ball, president, 2024 West 62nd Street, Los Angeles.

Sedimentary beds of magnesite occur on contact of dolomite and schist, dolomite being the hanging wall, schist and gneissoid granite the footwall. The strike of the beds of magnesite is east, the dip 50° S. Shallow trenches, shafts, and open cuts indicate the magnesite beds have a thickness of at least 300 feet. There are two strata of dolomite about 150 feet apart, with magnesite between the dolomitic outcrops.

The magnesite is developed by a trench 120 feet in length, 6 feet in depth, cut across the magnesite beds in northerly direction. There are also a number of shafts from 10 to 50 feet in depth on the different claims. The magnesite is exposed for a length of 6000 feet indicating a large tonnage of ore.

Analyses of samples of selected material

	No. 1	*No. 2*	*No. 3*
Silica (SiO_2)	6.80%	3.70%	3.71%
Aluminum (Al_2O_3 and iron Fe_2O_3)	2.00%	1.92%	1.00%
Calcium oxide (CaO)	2.12%	1.73%	0.42%
Magnesium oxide (MgO)	41.72%	43.70%	42.95%
Carbon dioxide (CO_2)	45.70%	49.80%	48.99%

Several hundred tons of magnesite have been mined and shipped to Minerals Processing Company of Los Angeles for calcining. Four men are employed sinking a shaft on the south end of the property.

New Trail Mining Company's Magnesite Deposit. The deposit of magnesite occurs on claims of the New Trail Mining Company situated 10 miles northwest of Cima, a station on the Union Pacific Railroad, in sec. 4, T. 15 N., R. 14 E., S. B.; owner, New Trail Mining Company, J. F. Kent, president, Riverside, California; Joseph Johnson, vice president, Cima, California; J. D. Loop, secretary, Cima, California.

The magnesite occurs along bedding planes of dolomitic limestone. The vein of magnesite is 2 to 4 feet thick, strike northeast, dip 45° SE. It has been developed by a number of shafts to a depth of 80 feet for a distance of 500 feet along its strike. The magnesite is dead white in color. It is reported that several hundred tons of ore was shipped to Chula Vista in 1918. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 390.

Richter Magnesite Deposit. It comprises two lode claims and two 160-acre placer claims situated on a low hill in the north end of Lucerne Valley in the SE¼ SE¼ sec. 15, T. 6 N., R. 1 W., 10 miles north of Lucerne and 35 miles by road northeast of Victorville; elevation 3300 feet; owner, Marter Mining Company, R. M. Richter, president and manager; L. B. Martin, secretary, 530 West Sixth St., Los Angeles.

There are two systems of magnesite veins that occur in dolomitic limestone. One series of parallel veins strikes N. 70° E., dip 45° NW. The other series strikes N. 20° W. and dips 70° W. The veins range in width from 2 inches to 18 inches. The development consists of a number of open cuts and shafts from 10 to 20 feet in depth. The principal development is on the north slope of the dolomite hill. Here an open cut has been made on N. 70° E. vein 50 feet in length and 10 to 15 feet in depth. This open cut exposes veins of magnesite up to 18 inches in width. On the northeast slope of hill there is an open cut on N. 20° W. vein about 30 feet in length and 6 to 10 feet in depth; also, a shaft 20 feet in depth. The vein exposed is 6 inches to 18 inches in width. From these workings about 60 tons of high grade magnesite has been mined. The magnesite is pure white in color.

Analysis of crude magnesite by Smith-Emery Company, Los Angeles, is as follows:

Silica (SiO_2)	0.84%
Iron (Fe_2O_3)	0.43%
Alumina (Al_2O_3)	2.77%
Calcium oxide	1.94%
Magnesium oxide (MgO)	43.00%
Carbon dioxide (CO_2)	50.80%
Total	99.78%

Two men are employed on development work.

White Moon magnesite mine comprises White Moon placer claim, in the NW.$\frac{1}{4}$ sec. 22, White Moon No. 2 placer claim in the NE.$\frac{1}{4}$ sec. 22, White Moon No. 3 placer claim in the SW.$\frac{1}{4}$ sec. 15, White Moon No. 4 placer claim in the SE.$\frac{1}{4}$ sec. 15, T. 8 N., R. 21 E., S. B., total 640 acres, in the Sacramento Mountains, in the Sunrise mining district, 11 miles southwest of Needles; elevation 2000 feet. Owners are B. E. Hubbard and William W. White and associates, 6263 Vesper Street, Van Nuys, California; under option to J. Rex Brown, 1850 Waterman Avenue, San Bernardino, California; subleased to American Magnesite Company of America, Irving Bromberg, president; A. Bromberg, secretary; M. I. Lieberson, manager; H. A. Pelton, engineer, 1349 Washington Boulevard, Los Angeles; J. Rex Brown, superintendent.

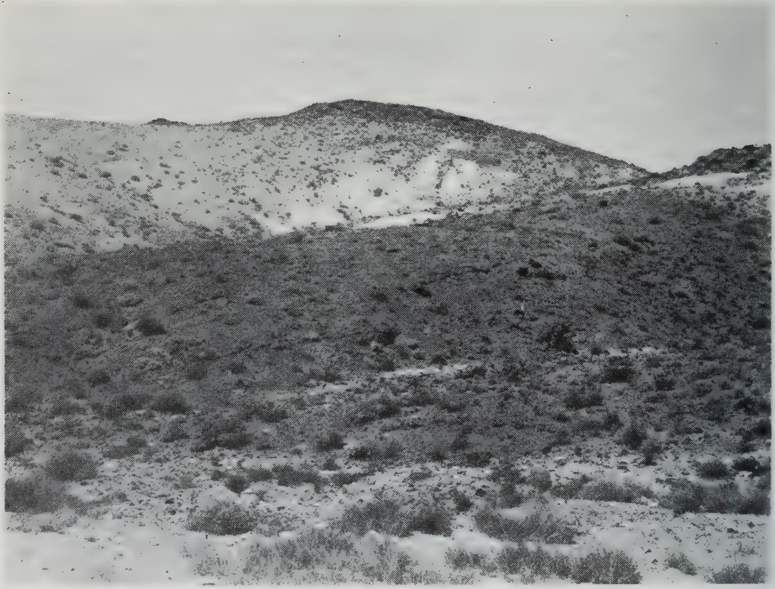

FIG. 22. White Moon magnesite deposit, Sacramento Mountains, 12 miles southwest of Needles.

A stratum of magnesite occurs along anticlinal fold in dolomite and overlies a thick series of volcanic rocks, andesite and andesitic breccia. The general strike is northwest, dips vary. The general dip of the stratum is 15° NE. The sedimentary bed of magnesite is intensely folded and tilted. There is not sufficient development work on the bed to determine its thickness which is probably about 8 feet to 10 feet. The dolomite beds overlie the bed of magnesite, having a thickness of about 8 to 10 feet. The exposure of magnesite can be traced on the surface for a distance of 750 to 1000 feet.

Development consists of a number of shallow trenches, short tunnels, and open cuts made at intervals along the bed of magnesite. Estimated tonnage of probable ore developed is stated to be 40,000 tons of commercial grade. Four hundred tons of ore was shipped to the Chula Vista plant.

A road 11½ miles in length from Needles to the deposit, is under construction. The company has acquired the Chula Vista calcining plant formerly operated by the Tycrete Chemical Corporation, Chula Vista, San Diego County. The plant has a capacity of 100 tons per day. They plan to ship the magnesite from deposit to Chula Vista for treatment. Six men are employed on construction of road and development work on an open cut on the southeast end of deposit.

Pumice and Volcanic Ash

Perlite Deposit (volcanic glass). It comprises 4 claims situated on the southeast slope of the Granite Mountains, 1 mile east of the Amboy-Kelso road and 18 miles by road northeast of Amboy, in sec. 10 (?), T. 8 N., R. 13 E., S. B.; elevation 3500 feet; owner, L. R. Harper, Los Angeles.

The outcrop of volcanic glass is 1800 feet in length by 750 feet wide, in andesite. The outcrop strikes N. 70° E. The volcanic glass is gray in color. It is reported, after heat treatment, it is converted into pumice and can be used for insulating material. Idle.

Ship Mountain Volcanic Ash Deposit. It comprises 3 claims situated in sec. 11 (?), T. 5 N., R. 15 E., S. B., on the southwest slope of Ship Mountain, 2½ miles southeast of Siam, a station on the Santa Fe Railroad; elevation 1700 feet; owner, Thomas Schofield, Amboy, California.

A bed of volcanic ash 30 feet in thickness is exposed by 3 open cuts. The volcanic ash is overlain by basalt. The volcanic ash is white to gray in color and of good quality. The bed strikes north and dips 25° E. Idle.

Salines

Under this heading are included, borax, nitrates, salt, soda, potash, and other alkaline salts. The main sources of the salines are the dry lake beds of the desert region of San Bernardino County.

The principal commercial production of the salines is made up of borax, salt, soda, potash, magnesium sulphate, and calcium chloride. Borax, soda, sodium-lithium phosphate and potash are recovered from the brines of Searles Lake, located in the northwestern part of the county. San Bernardino County is one of the chief sources of potash in the United States.

Nitrates of sodium, potassium, and calcium have been found in various places in the desert regions of the county but no deposits of commercial value have been developed. The principal deposits of salt occur in the dry lake beds of Bristol Lake near Amboy, Cadiz Lake, and Danby Lake, near Salt Marsh. There are extensive deposits of salt in the Avawatz Mountains but due to the distance from transportation there has been no commercial production.

The principal production of sodium salts in the county is recovered from the brines of Searles Lake in the form of soda ash, bicarbonate of soda, and trona, a double salt of Na_2CO_3 and $NaH\ CO_3$; and from Dale Lake, where a plant was built in 1942 for the recovery of sodium sulphate and production was made during the year.

The production of calcium chloride came from one plant on Bristol Lake, being obtained as a by-product in the refining of salt.

Borax

The only production of borax is crystallized borax prepared by evaporation of the brines from Searles Lake.

Magnesium Salts

American Magnesium Company, Los Angeles. On the patented placer mining claims owned by this company, located in T. 25 S., R. 46 E., M. D., 35 miles east of Trona, there is a deposit of magnesium sulphate.

Bibl.: State Mineralogist's Report XXVII, p. 392.

Niter

The occurrence of niter in the low, rolling hills along the Amargosa River has been known since the early eighties. The niter beds are situated in the northern part of San Bernardino County, extending across the boundary line into Inyo County.

Bibl.: State Mineralogist's Reports XV, pp. 890-891; XXVII, p. 392; Bull. 24, pp. 174-178.

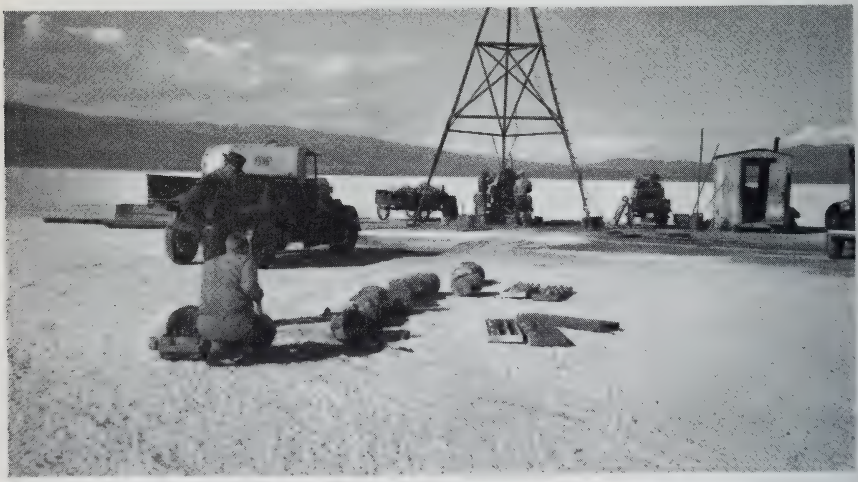

FIG. 23. Coring a new well for potash-borax-soda-bearing brine; American Potash and Chemical Company, Searles Lake. *Photo by Walter W. Bradley. Reprinted from Bull. 121, California Mineral Production for 1940.*

Potash

American Potash and Chemical Corporation, F. Cecil Baker, president; Peter Colefax, secretary-treasurer, 70 Pine Street, New York, New York; R. W. Mumford, general manager, Trona, California. The plant is situated on the northwest shore of Searles Lake; elevation 1600 feet. Holdings comprise about 3230 acres, with leases covering about 6000 acres of Searles Lake, secs. 17, 21, 22, 23, 24, 25, 26, 27, 28, T. 25 S., R. 43 E., M. D. The saline deposits of Searles Lake comprise several distinct areas: (1) the central area of firm crushed salt, consisting of the main salt deposit or crystal area, which is 13 square miles in extent; (2) the playa zone, including central salt area and a broad surrounding margin of salt incrusted mud and sand, composed of mud and mixed alluvial material. The area of the playa zone is about 60 square miles. The average depth of the salt in the main part of the deposit is 70 feet.

The brine from Searles Lake is composed of five definite materials: halite, trona, hanksite, borax, glaserite, burkeite.

The composition of Searles Lake brines is as follows:

Sodium carbonate (Na_2CO_3)	4.86%
Sodium chloride (NaCl)	16.36%
Sodium sulphate (Na_2SO_4)	6.85%
Potassium chloride (KCl)	4.74%
Sodium borate ($Na_2B_4O_7$)	1.50%
Total solids	34.38%

The base of the deposit consists primarily of sodium carbonate and sodium bicarbonate. There is an increase in the upper parts of the deposit of sodium sulphate and a concentration of sodium chloride at the top of the deposit.

Method of Treatment of Brines: Ten wells have been sunk in the center of the Crystal Lake area and the brine is pumped by centrifugal pumps through an insulated pipe line 10 inches in diameter, a distance of 3 miles to large steel storage tanks having a capacity of over 2,000,000 gallons of brine. The brine from storage tanks is pumped to two units of triple effect evaporators, each unit consisting of three pans; each pan is composed of a heater flashing chamber and vapor lines.

Process: The process used is evaporation and crystallization. The brine treated carries from 4.75 to 5 percent KCl and has a temperature of 72° F. Since 1931[13] the plant capacity has been increased and a sodium sulphate unit added. The products produced are potash, borax, boric acid, soda ash, salt cake, sodium-lithium phosphate and bromine. Total number employed is 600.

Bibl.: State Mineralogist's Reports XVII, pp. 357-358; XXVII, pp. 392-394; Chamber of Mines & Oil Bull., July, 1919, "Potash of Searles Lake," by Alfred De Ropp, Jr.; American Chemical Society, Monograph Series No. 49, "Industrial Development of Searles Lake Brines," by John E. Teeple, Ph.D.

Salt

The salt resources of San Bernardino County occur in the Avawatz Mountains in the northern part of the county and on Bristol Lake, Cadiz Lake, and Danby Lake, in the southeastern quarter of the county. The estimated reserves of salt in Bristol Lake, Cadiz Lake, and Danby Lake are approximately 100,000,000 tons, and are ample to meet any and all requirements. At present, the main production is from Bristol Lake, with a small production from Danby Lake.

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[13] See Tucker, W. B., and Sampson, R. J., op. cit.

The large deposits of rock salt in the Avawatz Mountains are undeveloped due to the distance from railroad transportation. There was an increase in the production of salt from Bristol Lake during 1942 and 1943 for shipment to the Basic Magnesium Company's plant at Las Vegas, Nevada, being used in the process for the production of magnesium metal. There was also an increased demand for salt as a water softener for the Metropolitan Water District. This caused the California Rock Salt Company to increase the capacity of its plant on Bristol Lake.

Avawatz Salt Deposits. These large deposits of rock salt are situated on the northeast slope of the Avawatz Mountains, in secs. 13, 16, 21, 22, 27, T. 18 N., R. 5 E., S. B., 15 miles northwest of Riggs and 50 miles by road north of Dunn Siding, on the Union Pacific Railroad; elevation 1000 to 1500 feet; owner, Avawatz Salt & Gypsum Company, H. H. Kerchoff, Jr., 2545 Raleigh Drive, San Marino, California.

The salt occurs as large deposits of rock salt in the Jumbo salt area, Salt Basin area, and Valley salt area. Rock salt of great purity is found in the above-mentioned areas. Individual beds are over 50 feet thick, interstratified with clay, sand, and anhydrite; total thickness and proportion of salt to insoluable material is unknown. In 1942, the Basic Magnesium Company, Las Vegas, Nevada, drilled the Jumbo salt area and it is reported one hole went through 1000 feet of salt. The salt is usually massive and does not show crystalline structure. The color is usually reddish or brown, though there are occasional seams of clear, white salt. Chemical analyses show purity as high as 98 percent.

Approximate estimates of the tonnage contained in the Avawatz Mountains:

Jumbo salt area	9,000,000
Salt Basin area	8,000,000
Valley salt area	5,000,000

During 1942 the property was under option to the Basic Magnesium Company, Las Vegas, Nevada, and this company drilled the different areas with encouraging results. Their option on the salt deposits was relinquished due to the distance of the deposits from railroad transportation. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 892-3; XVII, p. 357; XXVII, pp. 395-396; Bull. 24, pp. 126-128; U. S. Geol. Survey Bull. 540, pp. 526-530.

Cadiz Dry Lake Salt Deposits. These salt deposits are located on Cadiz Lake, in T. 2 and 3 N., R. 15 E., S. B., 12 miles west of Milligan, a station on the Santa Fe Railroad; elevation 600 feet. This dry lake is about 25 square miles in area. Its most northerly end is some 12 miles south of Cadiz and about 9 miles west of Chubbuck. The most southerly end is about 12 miles west of Milligan.

The surface of Cadiz Lake is made up of sand and clay mixed with gypsum. Rock salt, crystalline gypsum, and a brine of sodium chloride and calcium chloride underlie this lake. The brine also contains the chlorides of potassium and magnesium. The salt beds are from 5 to 7 feet thick. The reserves of rock salt and brine probably amount to 25,000,000 tons of salt. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 396; U. S. Geol. Survey Bull. 578, p. 695; Bull. 669.

California Rock Salt Company, W. F. Biedebach, president and manager. Offices are at 2465 Hunter Street, Los Angeles. The plant of the California Rock Salt Company, the only company now producing from Bristol Lake, is located 3 miles east of Amboy, at Saltus, a loading spur on the Santa Fe Railroad. The plant is located in the center of sec. 11, T. 5 N., R. 12 E., S. B.; elevation 600 feet. The pit is 4 miles southwest of the plant and transportation from the pit to the plant is by narrow gauge, gasoline locomotive haulage. Ten cars of 5 cubic yards are hauled each trip. The holdings of the company comprise 6000 acres; estimated reserves underlying this 6000 acres will approximate 60,000,000 tons. The mineral, halite, sodium chloride (NaCl), occurs as a crystal body underlying the lake. The surface of the playa lake is composed of sand, clay, and gypsum. The surface material is thinnest at the southern portion of Bristol Dry Lake and thickens to the north. In the southern portion of the dry lake, the overburden does not exceed 3 feet in thickness. On the property of the California Rock Salt Company, the overburden is about 4 feet thick. The crystal body is of high-grade halite, crystallized in cubes, filled with brine which is principally calcium chloride. Some mud, largely of volcanic ash origin, is found with the salt body. The salt body has an average thickness of 5 feet. Underlying this salt body is a bed of bluish clay 8 to 10 feet in thickness and then another bed of salt reported to average 5 feet in thickness. Because of the immense reserve of salt in the upper stratum, no consideration has been given to mining the second or lower stratum of salt.

In mining the salt the overburden is removed by a 2½-cubic yard, 70-foot boom, diesel powered dragline. The stripped salt is drilled with augers and blasted with dynamite. The dragline loads the broken salt into 5-yard dump cars. Ten cars are hauled by gasoline locomotive 4 miles to the plant at Saltus. The cars are dumped over 12-inch bar grizzly into crusher bin; from bin to jaw crusher, crushed to 2-inch size which is further reduced by rolls to ¾-inch size. A series of inclined spiral conveyors conveys the minus ¾ mesh product to bins or direct to railroad cars. Hot salt water is introduced into the spiral conveyors to wash from the salt the clay and other impurities. The analysis of salt after washing shows it to carry 1½ percent moisture. When thoroughly dried salt is required, the last spiral conveyor can be discharged into rotary kiln dryer.

Wash water is obtained from wells 100 feet deep at the plant. Recently the plant capacity has been increased 400 tons of product per day. Mining, handling, and processing the salt requires a crew of 30 men per day. Products produced are salt and calcium chloride.

Bibl.: State Mineralogist's Reports XVII, p. 357; XXVII, p. 396; U. S. Geol. Survey Bull. 669.

Danby Dry Lake Salt Deposits. Danby Dry Lake is 10 miles long and about 3 miles wide. It is located in portions of T. 2 N., R. 17 E. and T. 2 N., R. 18 E. and T. 1 N., R. 18 E., S. B., at Salt Marsh and 26 miles southeast of Cadiz; elevation 620 feet; owners, Mrs. R. B. Evans, Pasadena, California, and Judge Russ E. Avery, Los Angeles; under lease to the Reeder Salt Company, J. W. Reeder, president and manager, South Pasadena, California. Holdings comprise 3660 acres. J. W. Reeder has located placer mining claims covering some additional 2500 acres. The known salt horizon covers an area of between 5000 to 10,000 acres.

An overburden of sand and silt varying from a few inches to as much as 8 feet overlies this salt bed. The bed of salt is from 5 to 10 feet in thickness. The salt is quite pure as analysis shows 98 percent sodium chloride. The estimated resources are from 25,000,000 to 50,000,000 tons. From the plant at Salt Marsh the crude, washed salt is shipped to refining plant of the Reeder Salt Company at South Pasadena, California, where it is refined for table salt. Six men are employed.

Hollar Chemical Company, Inc. (formerly known as Saline Products Co., Inc.), X. H. Hollar, vice president and manager. Offices are at 2000 Santa Fe Avenue, Los Angeles. This company holds title to 10 square miles of Bristol Lake. The plant is located at Funston, a siding on the Santa Fe Railroad, secs. 21 and 22, T. 5 N., R. 12 E., 5 miles south of Amboy. The salt and bittern pits are located on the southern side of Bristol Lake, about 5 miles south of the plant.

The deposit of rock salt is from 3 to 6 feet in thickness, being overlain with 4 feet of sand and clay mixed with gypsum. The plant has not been under operation for 3 years. It is reported that the Sacramento Industries Company of Sacramento, California, has an option on the property and is planning to remodel the plant. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 397.

Soda

Searles Lake, the principal source of borax and potash in San Bernardino County, is also the principal source of soda in the county.

American Potash & Chemical Company and West End Chemical Company are the principal producers of soda ash, which is recovered from the brines of Searles Lake.

Deposits of sodium sulphate occur at Dale Dry Lake, at Dale, close to the southern boundary of San Bernardino County. Chemical Mines Company, of Los Angeles, built a plant in 1940 and started production of sodium sulphate in 1941.

Dale Lake sodium sulphate deposit comprises nine 160-acre placer claims totaling 1440 acres, situated in secs. 26, 27, 34 and 35, T. 1 N., R. 12 E., S. B., 17 miles east of Twenty-nine Palms and 30 miles south of Amboy, a station on the Santa Fe Railroad; elevation 1180 feet; owner, Chemical Mines Company, J. E. Bush, president; C. H. Hobson, secretary, 1204 West 31st Street, Los Angeles. The property was acquired under lease in March 1939 by the Desert Chemical Company, H. D. Dargert, president; Ray Owen, manager, 4031 Goodwin Avenue, Glendale, California.

The brines of the lake contain 22 percent sodium chloride and 7 percent sodium sulphate at a temperature of 70° F. Seven wells about 150 feet apart near the center of the lake have been drilled to depths of 150 feet. The brine from these wells is pumped to four 7-acre crystallizing vats or spray ponds. The central pumping plant is located at the junction of the four crystallizing vats, with an intake from each vat. Spraying is under operation during the winter months for the recovery of mirabilite, glauber salt, hydrous sodium sulphate, $Na_2SO_4 . 10 H_2O$. The sodium sulphate separates from the solution by evaporation or by chilling of its saturated solutions below 33° C. The concentrated solution from crystallizing vats is pumped by 15-horsepower, electric-driven

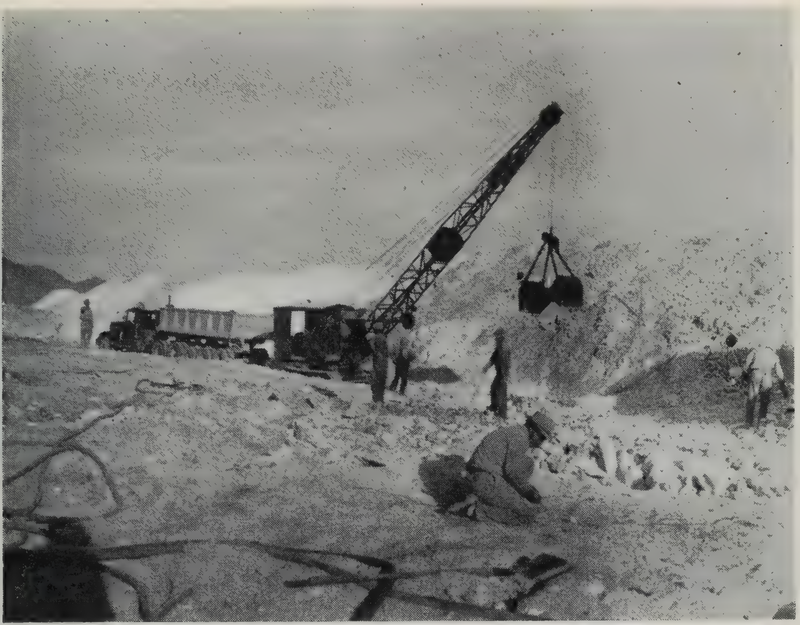

FIG. 24. Dale Lake sodium sulphate deposit, Desert Chemical Company, Dale.

turbine pumps to two 5-acre finishing vats where sodium sulphate separates from the brine as glauber salt. The sodium chloride from the vats is pumped to one 80-acre vat from which it flows to four 5-acre vats for evaporation and recovery of NaCl. Sodium sulphate is harvested during dry, summer months. Production started January 1940 and yearly production of sodium sulphate amounted to 15,000 tons; also shipping sodium chloride to Basic Magnesium Company, Las Vegas, Nevada. On the southwest end of the lake, there is a bedded deposit of thenardite Na_2SO_4, anhydrous sodium sulphate, 600 feet in width and 4000 feet in length, average thickness of 6 feet, with 6 feet to 8 feet of overburden. The overburden is stripped off and thenardite mined and hauled by truck to central washing plant where clay and sand is washed out. Thenardite is reported to carry 94 percent sodium sulphate. They are at present shipping 100 tons per day. The sodium sulphate is hauled by diesel trucks having a capacity of 30 tons each, to Amboy.

The thenardite is dumped from trucks into 50-ton ore bin, then to roll type of crusher and crushed $\frac{1}{8}$-inch size and conveyed by 36-inch belt conveyor to two 100-ton circular, wooden bins. From bins, it is loaded into box cars for shipment to pulp plants. Crystallized sodium sulphate also goes to circular bins for shipment.

Two fresh water wells 400 feet in depth are located 1 mile west of the plant and water for plant and camp is pumped by Pomona turbine pumps, each driven by a 15-horsepower motor. Electric power plant consists of 300-horsepower, 4-cylinder, Fairbanks-Morse diesel engine, direct-connected, with 170 K. V. A. generator to furnish electric power for pumps and lights for camp. Twenty men are employed.

Bibl.: State Mineralogist's Report XXXVI, p. 63.

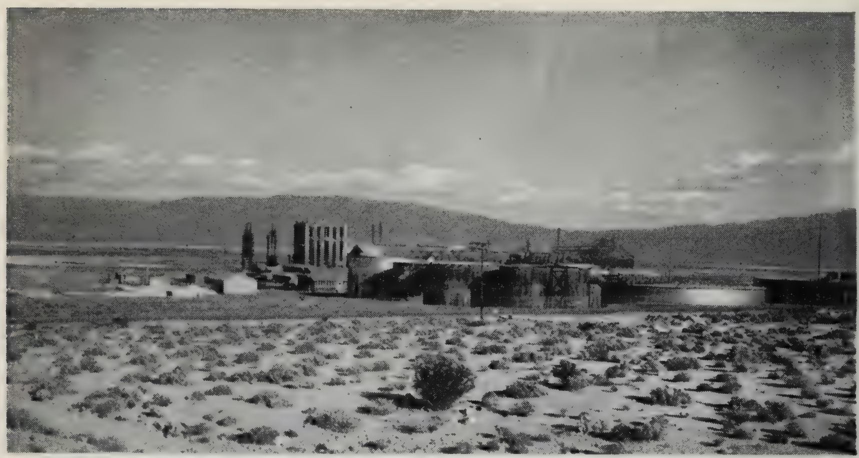

FIG. 25. Plant of West End Chemical Company, Searles Lake. *Photo by Walter W. Bradley. Reprinted from Bull. 121, California Mineral Production for 1940.*

West End Chemical Company, E. F. Smith, president; Norman P. Ellis, secretary. Offices are in Latham Square Building, Oakland, California. Henry J. Hellmers is general manager, West End, California. The plant is on the west shore of Searles Lake, 4½ miles south of Trona, at West End, secs. 5, 6, T. 26 S., R. 43 E., M. D. The property comprises about 3000 acres and they have a lease of some 3000 acres on Searles Lake. The plant capacity has been doubled since 1931.[14]

The concentrated brine is pumped from evaporation ponds to settling tanks. The brine from settling tanks is pumped to carbonate towers, the process being to carbonate the vapors and so remove all of the sodium carbonate, as sodium bicarbonate. This is filtered off and calcined to make soda ash. The products produced are soda ash and borax. The dolomite to generate CO_2 gas is hauled by trucks from a quarry owned by the company located north of Trona in Inyo County.

Water to operate the plant flows through a 6-inch pipe line from springs owned by the company 17 miles west of Searles Lake. Sixty to 70 men are employed.

Bibl.: State Mineralogist's Report XXV, p. 399.

Silica

Emsco quartzite deposit, leased from Southwestern Portland Cement Company, is approximately 6 miles east and a little north of Victorville. It is at the east end of the limestone quarries of the cement company.

This quartzite occurs on the footwall or south side of the extensive limestone bed which traverses this area for several miles. Its strike is east, dip about 40° N. Since it is resistant to erosion, in places it forms low hills which rise 200 feet or more above the surrounding rocks. It is reported that, in places, this material is 96 to 97 percent silica.

The standard gauge railroad of the Southwestern Portland Cement Company has been extended to within about 200 yards of the present quarry face which is some 300 feet long in a north-south direction and from nothing to 75 feet high. The material is loaded by 1-cubic yard power shovel into 5-ton trucks and hauled to the railroad. The material is used for the manufacture of refractory brick lining.

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[14] Tucker, W. B., and Sampson, R. J., op. cit.

About eight men are employed.

Bibl.: State Mineralogist's Report XXVII, pp. 376-377.

Leahy Ganister Deposit. The deposit is situated in a low range of hills northwest of the Mojave River, in section 36, T. 9 N., R. 4 W., S.B., 4 miles northwest of Hodge, a station on the Santa Re Railroad; elevation 2500 feet; owner, W. E. Leahy, Los Angeles.

A massive outcrop of quartzite occurs in rhyolite. The outcrop strikes northwest and is 500 feet in length, 200 feet wide and 150 feet high. It was formerly worked by the Emsco Refractories Company, Los Angeles. The quarry is located on the north slope of outcrop. Idle.

McKnight, H. E., of Los Angeles, has a deposit of Cornish stone in section 16, T. 7 N., R. 2 E., S.B. It is at Willis Well on the east slope of Ord Mountains, 20 miles north of Box S Ranch. Holdings comprise 640 acres.

White Cloud Silica Deposit. It comprises three 160-acre placer claims situated in the Granite Mountains, in the SE$\frac{1}{4}$ sec. 35, T. 29 S., R. 44 E., M.D., 1 mile south of Pilot Knobb, 3 miles west of Copper City and 40 miles north of Barstow; elevation 4800 feet; owners, Mrs. Hazel Cuddeback and Mrs. Francis Cuddeback, Bakersfield, California. In 1941 and 1942 the deposit was under lease to J. E. Lewis and L. P. Harper, Los Angeles. About 100 tons of silica was mined and shipped to Gladding-McBean Company, Los Angeles.

Three parallel quartz veins occur in granite, strike N. 20° E., dip 50° E. The veins are 10 to 20 feet in width. Developed by open cuts. The silica mined is pure white in color and free of iron. Analysis: 99.8 percent SiO_2. Idle.

Strontium

Deposits of strontianite ($SrCO_3$) and celestite ($SrSO_4$) occur in San Bernardino County. Large deposits of celestite occur in the lake beds containing salt and gypsum in the Avawatz Mountains, on the property of the Avawatz Salt & Gypsum Company. There are also extensive deposits on the southeast slope of the Cady Mountains, 4 miles north of Argus, a siding on the Santa Fe Railroad, and 6 miles northwest of Ludlow. Pebbles of celestite are found on the south shore of Bristol Dry Lake, 9 miles south of Amboy. Strontianite, the carbonate, occurs in the clay beds 10 miles north of Barstow.

Bibl.: State Mineralogist's Reports XV, pp. 898-899; XVII, pp. 366-367; XXVII, p. 399; U. S. Geological Survey Bull. 540, pp. 526-531; U. S. G. S. Bull. 660-1.

Avawatz Celestite Deposits. The deposits occur on the northeast slope of the Avawatz Mountains, in secs. 13, 16, 21, 22, 27, T. 18 N., R. 5 E., S.B., 15 miles northwest of Riggs, and 50 miles by road north of Dunn Siding, on the Union Pacific Railroad; elevation 1000 to 1500 feet; owner, Avawatz Salt & Gypsum Company, H. H. Kerchoff, Jr., 2545 Raleigh Drive, San Marino, California.

The celestite deposits occur in the lower lake beds interbedded with gypsum; other places it is associated with sandy beds overlying the

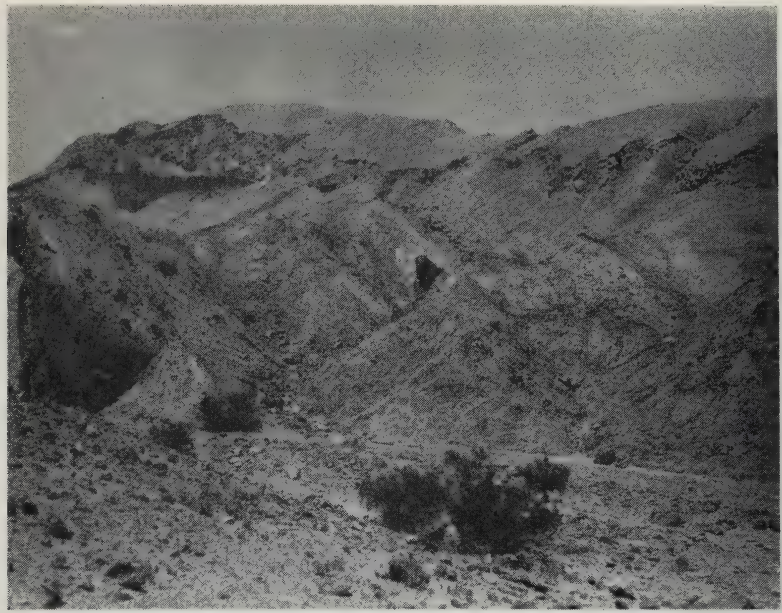


FIG. 26. Big Gypsum Hill celestite and gypsum deposits, Avawatz Salt and Gypsum Company, Avawatz Mountains.

gypsum beds. The celestite beds outcrop as reefs of hard, dark-brown rock, breaking in angular fragments along jointing and bedding planes. The celestite beds are 2 to 6 feet in thickness. The color of the celestite varies from brown to white. The principal occurrence is on Big Gypsum Hill north of Denning Springs Wash. On the east slope of the hill, there is a bed of celestite overlying a massive bed of gypsum. The bed strikes northwest and dips 40° NE. It is about 4 feet thick and can be followed along its exposure for 1000 feet. It is exposed by an open cut 50 feet in length and also by a trench 50 feet in length and 4 feet in depth. On the west slope of the hill, a tunnel has been driven in gypsum N. 20° W., 50 feet. Strata of celestite were cut at intervals in the tunnel and were from 2 to 4 feet thick. Samples taken from this deposit are reported to carry 85 percent $SrSO_4$. Idle.

Bristol Lake Celestite Deposit. On the south edge of Bristol Lake, about 2 miles southwest of the Desert Properties Company's plant and 9 miles southwest of Amboy, in secs. 4, 7, 8, T. 4 N., R. 12 E., S. B., nodules of celestite from walnut size up to 6 inches occur in clay above gypsum beds.

During 1942, A. C. Becker and L. Stevenson of Los Angeles attempted to harvest the nodules of celestite by road plow to a depth of 18 inches for shipment to the DuPont Company. These parties plowed up ten acres on the property owned by Desert Properties Company, Los Angeles. The attempt to recover the celestite was not successful.

DuPont Company owns two 160-acre patented claims in secs. 19 and 30, T. 8 N., R. 7 E., S.B., in the Cady Mountains, about 4 miles northwest of Argus Siding on the Santa Fe Railroad and 6 miles northwest of Ludlow.

The celestite deposit occurs in dolomite, is about 150 feet in width and traceable for some 2000 feet. The beds of celestite strike east, dip 45° N. Developed by open cuts and trenches. A large tonnage of celestite was mined from an open cut 200 feet in length by 50 feet in width and 15 feet deep during 1918. The grade of material mined is reported 85 percent $SrSO_4$. The celestite is brown in color. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 898-899; XVII, pp. 366-367; XXVI, p. 323; XXXVI, p. 254; U. S. G. S. Bull. 540, pp. 526-531; Bull. 660-I.

Rowe and Buehler Celestite Deposit. It comprises two 160-acre placer mining claims situated in the Cady Mountains, in the SE¼ sec. 19 and the NW¼ sec. 30, in T. 8 N., R. 7 E., S. B., 4 miles northwest of Argus, a siding on the Santa Fe Railroad and 6 miles northwest of Ludlow; owners, Wesley N. Rowe, Rosemead, California, and William C. Buehler, Pasadena, California.

Bedded deposit of celestite occurs in dolomite. The beds strike east and dip 40° to 50° N. Widths vary from 2 to 26 feet. Analyses indicate from 76 to 84 percent $SrSO_4$. Color of celestite is white to brown. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 254.

Talc

Acme talc deposit, comprising 7 patented claims and 4 locations, is in sec. 4, T. 19 N., R. 8 E. and secs. 32 and 33, T. 20 N., R. 8 E., in the Kingston Mountains, some 15 miles southeast of Tecopa; elevation about 3000 feet; owner, Western Talc Company, F. H. Savell, president, 1901 East Slauson Avenue, Los Angeles. Charles Jenkins is in charge of mine operations.

The patented claims are Snow Goose No. 1, 2, and 3, Talc Mine, Talc Glass, Talc No. 3 and Talc No. 4.

The talc occurs along the contact of dolomitic limestone and greenstone. The dolomite forms the hanging wall, the greenstone is on the foot. The strike of the deposit is north, dip 50° to 55° E. The talc occurs as a series of overlapping lenses along this contact, which, in places, is as much as 75 feet in width.

Development is distributed over more than a mile in length of this zone and the lenses are up to 34 feet wide, with an average width of 10 feet. The talc is white in color and free from grit and lime. The property has been developed by 4 shafts and numerous tunnels and open cuts. The accompanying map is not up-to-date, much work having been done which is not shown thereon.

Shaft No. 1, near the north end of the Talc Glass claim, sunk 100 feet on 55° inclination: on 58-foot level, drift south 100 feet; on 90-foot level, drift north 340 feet. A winze has been sunk to the 134-foot level at the east end of a crosscut which is 50 feet north of the shaft.

Shaft No. 2, approximately 1300 feet south of No. 1, has been sunk 158 feet on about a 50° inclination. On the 130-foot level a drift has been driven 630 feet north. Above this there are several hundred feet of drifts, raises and crosscuts, most of which are now caved. It is reported that the talc was mined 20 feet in width here.

Shaft No. 3 on Talc claim No. 3 is 850 feet south of No. 2 shaft. It has been sunk 100 feet on a 55° inclination. On the 100-foot level drifts have been driven N. 100 feet and S. 100 feet. Mining is carried on from a sub-level some 65 feet below the surface. Eight raises have been holed through to the surface. The average width of talc in these workings is estimated to be 10 feet.

Shaft No. 4 is on the Talc Mine claim some 1300 feet north of shaft No. 1. It has been sunk to a depth of 90 feet. On the 80-foot level a drift has been driven south 600 feet. This drift will, in the next 200 feet, reach a point below a glory hole which was worked from tunnel No. 1 which is 10 feet lower than the collar of No. 4 shaft. This glory hole is 100 feet long, 30 feet wide and 15 feet deep.

It is estimated that these workings have blocked out a large tonnage of talc. At shaft No. 3 alone, it is believed that 50,000 tons are available in present workings.

Equipment at No. 3 shaft consists of 135-cubic foot compressor, belt-driven by gas engine; 30-horsepower gas-engine hoist. Ore is raised in 1½-ton skip to 2 bins having a capacity of 100 tons. At No. 6 tunnel there is a 110-cubic foot portable compressor. No. 4 shaft is equipped with a 30-horsepower gas hoist and a 90-cubic foot compressor. The camp consists of cook house, bunk house, two residences and two tent houses.

Shipments are made at the rate of about 10,000 tons per year. Shipments have aggregated more than 100,000 tons. The talc is hauled to Dunn Siding on the Union Pacific Railroad. Some 8 men are employed.

Booth mine is in the Kingston Mountains, 12 miles southeast of Tecopa, in sec. 9 (?), T. 19 N., R. 10 E., S. B.; owner, Sierra Talc Company, Ferris Booth, president; Franklin Booth, secretary and manager; Don Kempher, superintendent, 333 West Second Street, Los Angeles.

The deposit occurs on a contact having a dolomite hanging wall and a diorite footwall. The strike is east, dip 25° to 30° N., width about 10 feet. It was developed by a tunnel driven west which is now caved at 250 feet from the portal where stoping began. Idle.

Desert talc and clay deposit, is in the Clark Mountains, 4 miles northwest of Paso Alto Service Station on the Las Vegas Highway, about 20 miles east of Baker, in sec. 30 (?), T. 16 N., R. 11 E., S. B.; owners, Messrs. Schrader and Johnson, of the Pomona Tile Company, Pomona, California.

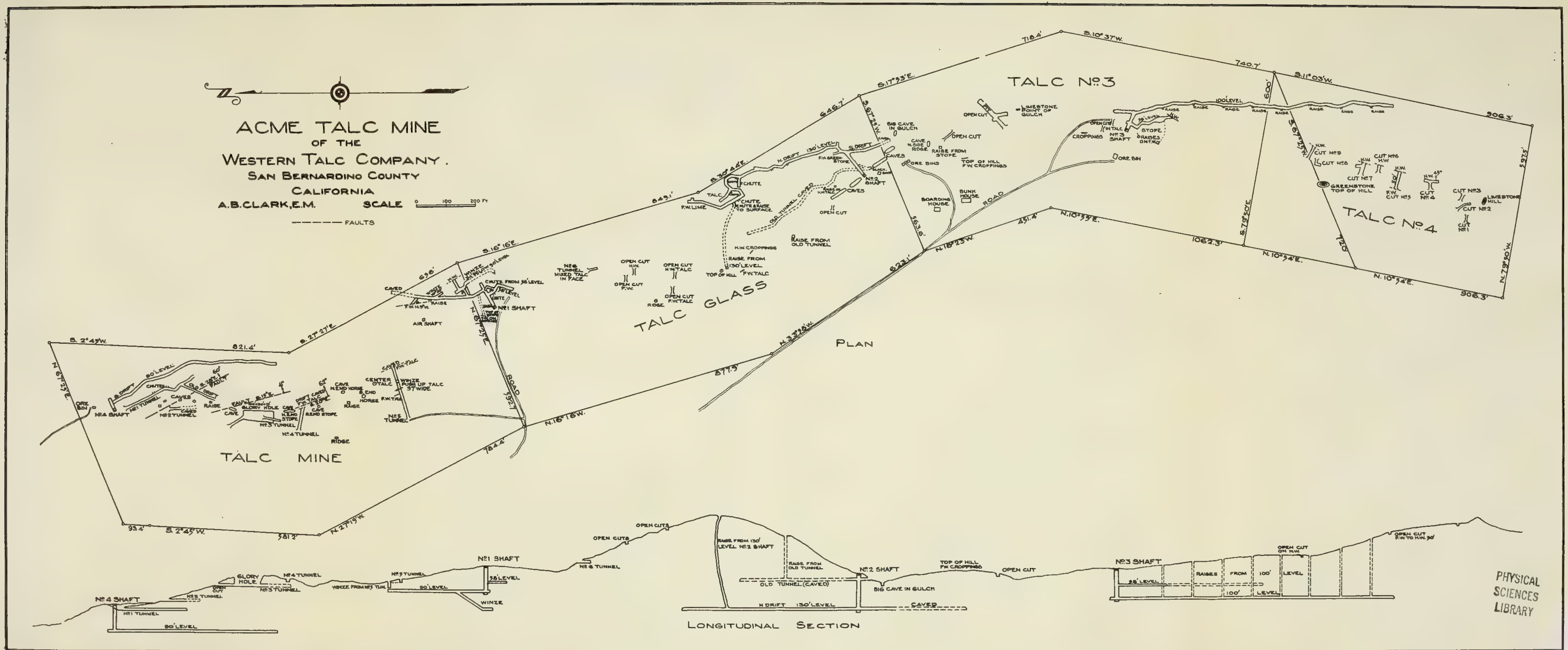
The talc occurs between dolomitic walls; strike northwest, dip 55° NE. The talc has an average width of about 8 feet and is opened for nearly 400 feet in length. It is white in color and is used in ceramics.

Development consists of a tunnel driven northwest 400 feet on the vein. There are two raises to surface 45 feet and 78 feet. Six stopes each about 30 feet long by 8 feet to 14 feet wide have been developed above the tunnel. The vein so far as developed, has no waste material in it.

The talc is shipped to Pomona Tile Company's plant in Pomona. Production is 45 tons per week. Three men are working.

Excelsior talc mine, comprising 13 claims, is on the southeast slope of the Kingston Mountains, sec. 27 ?, T. 19 N., R. 11 E., S. B., 28 miles north of Valley Wells and about 30 miles southeast of Tecopa; owner, Southern California Minerals Company, 320 South Mission Road, Los Angeles.

PLATE VI


ACME TALC MINE
OF THE
WESTERN TALC COMPANY.
SAN BERNARDINO COUNTY
CALIFORNIA
A.B. CLARK, E.M.
SCALE
0
100
200 FT
FAULTS
PLAN
TALC MINE
TALC GLASS
TALC Nº3
TALC Nº4
S. 2°45' W.
821.4'
S. 27°27' E.
636'
S. 16°16' E.
649.1'
S. 30°44' E.
646.7'
S. 17°53' E.
718.4'
S. 10°37' W.
740.7'
S. 11°03' W.
906.3'
597.5'
N. 79°50' W.
906.3'
N. 10°54' E.
1062.3'
N. 10°55' E.
451.4'
N. 18°23' W.
623.1'
N. 33°58' W.
577.9'
N. 16°18' W.
784.4'
N. 27°19' W.
581.2'
93.4'
S. 2°45' W.
N. 67°23' E.
N. 67°27' E.
592.1'
S. 67°25' W.
563.6'
600'
S. 79°50' E.
720'
ORE BIN
Nº4 SHAFT
Nº1 TUNNEL
Nº2 TUNNEL
Nº3 TUNNEL
Nº4 TUNNEL
Nº5 TUNNEL
Nº6 TUNNEL MIXED TALC IN FACE
90' LEVEL
S. DRIFT
CHUTE
CAVES
CAVED
RAISE
FAULT
GLORY HOLE
CAVE
N. END STOPE
S. END STOPE
DRIFT CAVED
F.W. TALC
CAVE N. END HORSE
S. END HORSE
CENTER TALC
WINZE PUSH UP TALC 37' WIDE
RIDGE
ROAD
Nº1 SHAFT
AIR SHAFT
F.W. H.W.
WINZE
CHUTE FROM 58' LEVEL
58' LEVEL
OPEN CUT H.W.
OPEN CUT F.W.
OPEN CUT H.W. TALC
OPEN CUT F.W. TALC
TOP OF HILL
RAISE FROM 130' LEVEL
H.W. CROPPINGS
RAISE FROM OLD TUNNEL
OLD TUNNEL CAVED
F.W. LIME
TALC
CHUTE & RAISE TO SURFACE
N. DRIFT 130' LEVEL
F.W. GREEN STONE
Nº2 SHAFT
OPEN CUT
BIG CAVE IN GULCH
CAVE N. SIDE RIDGE
RAISE FROM STOPE
ORE BINS
TOP OF HILL F.W. CROPPINGS
BOARDING HOUSE
BUNK HOUSE
LIMESTONE POINT OF GULCH
CROPPINGS
IN TALC
Nº3 SHAFT
STOPE
RAISES ON F.W.
100' LEVEL
RAISE
H.W.
CUT Nº9
CUT Nº8
CUT Nº7
CUT Nº6
CUT Nº5
CUT Nº4
CUT Nº3
CUT Nº2
CUT Nº1
GREENSTONE TOP OF HILL
LIMESTONE HILL
LONGITUDINAL SECTION
GLORY HOLE
OPEN CUT
WINZE FROM Nº5 TUN.
OPEN CUTS
Nº6 TUNNEL
RAISE FROM 130' LEVEL Nº2 SHAFT
RAISE FROM OLD TUNNEL
OLD TUNNEL (CAVED)
N DRIFT 130' LEVEL
CAVED
BIG CAVE IN GULCH
TOP OF HILL F.W. CROPPINGS
OPEN CUT ON H.W.
RAISES FROM 100' LEVEL
100' LEVEL
OPEN CUT F.W. TO H.W. 90'

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Reprinted from October 1937 *California Journal of Mines and Geology*, to accompany report by W. B. Tucker and R. J. Sampson, October 1943.

The talc bed occurs between a dolomitic hanging wall and a serpentine footwall; strike is N. 45° W., dip 45° SE.; the width is 15 to 50 feet, average about 20 feet. The talc is white and the lime content is low. It has been developed by tunnels. Upper tunnel has been driven northwest 800 feet. The lower tunnel, 165 feet on the dip below upper tunnel, has been driven northwest 1000 feet. At 450 feet from the portal, there is a winze 110 feet deep with levels at 50 feet and the bottom.

The owners have been shipping since 1936. Shipments aggregate about 10,000 tons. At present they are shipping 100 tons per month. The material is loaded at Dunn Siding about halfway between Yermo and Kelso on the Union Pacific Railroad.

Equipment consists of 105-cubic foot compressor and air tugger, at winze.

This company had to build 21 miles of road to make the property accessible. Three men are working.

Monarch mine is in the Ibex Mountains, 26 miles south and west of Shoshone and a quarter of a mile north of Ibex Spring; in T. 19 N., R. 5 E., S. B.; owners, Messrs. Morris and Corey, of Los Angeles; leased to Sierra Talc Company, 333 West Second Street, Los Angeles.

Here, between a dolomitic footwall and a greenstone hanging wall occurs a large lens of white, fibrous talc suitable for use in the paint and textile industries. The strike is N. 12° E., dip 50° E. Its length is 200 feet and it is as much as 100 feet wide; average 40 feet to 50 feet in width.

Development consists of a tunnel driven 275 feet on the hanging side of the vein with some 1200 feet of crosscuts and raises. Sixty-five feet below this tunnel a crosscut has been driven N. 80° W. 250 feet to the vein which has just been reached.

Equipment consists of 110-cubic feet portable compressor. Shipments from Dunn Siding to Los Angeles average about 400 tons per month. Six men are employed.

Sheep Creek Talc Deposits. It comprises 3 claims located north of Sheep Creek Springs on the north slope of the Avawatz Mountains, in secs. 5 and 6, T. 17 N., R. 6 E., S.B., 12 miles northwest of Riggs and 50 miles by road north of Dunn, a siding on the Union Pacific Railroad; elevation 1500 feet; owner, Avawatz Salt & Gypsum Company, H. H. Kerchoff, Jr., president and manager, 2545 Raleigh Drive, San Marino, California.

The talc deposits occur on contact of dolomite and gabbro, strike northwest, dip 65° SW. Talc outcrops for a distance of 3000 feet. Width varies from 15 to 50 feet. Average width is 30 feet. The talc where exposed in open cuts and tunnels is pure white to light gray in color and varies in hardness from solid outcrops which are moderately hard to very soft, crumbly masses. The highest grade talc is found near the contact of diorite or gabbro and is probably 8 to 12 feet thick. It is estimated that the tonnage that could be mined from these deposits is 400,000. Development consists of a tunnel driven from Sheep Creek northwest 150 feet, in impure talc on the contact of gabbro and limestone, several hundred feet in elevation below outcrop. There are also a number of open cuts and shallow tunnels along the outcrop for a distance of 2000 feet.

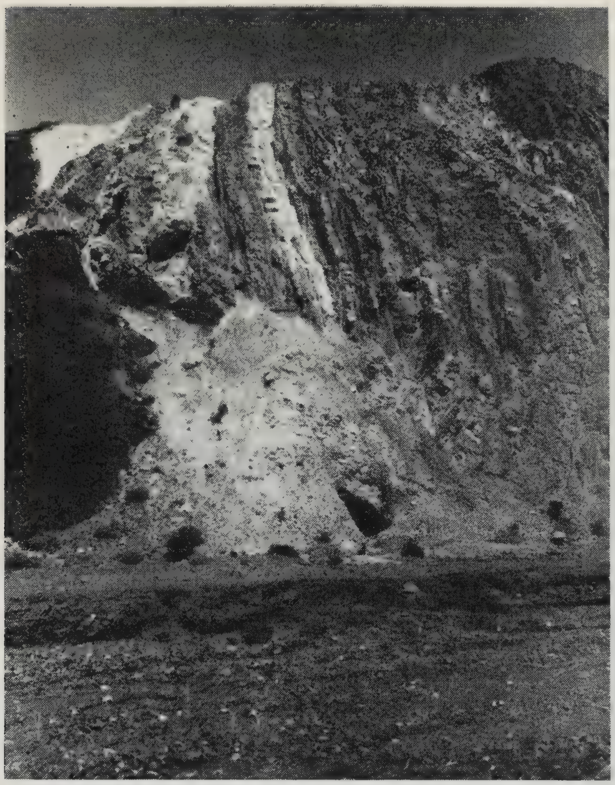

FIG. 27. Sheep Creek talc deposit, Avawatz Mountains; Avawatz Salt and Gypsum Company.

Analysis of the talc—U. S. Geological Survey

Silica (SiO_2)	60.20%
Magnesium oxide (MgO)	27.98%
Calcium oxide (CaO)	2.60%
Aluminum (Al_2O_3)	1.25%
Iron (Fe_2O_3)	2.50%
Water (H_2O)	5.70%

Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 368-369; XVIII, pp. 114-115; XXVII, p. 400.

Silver Lake deposit (formerly Tremolite or Pacific Coast Talc Company) is in sections 20 and 21, T. 16 N., R. 9 E., S.B., on the northwest slope of Shadow Mountains, 10 miles northeast of Silver Lake, a station on the now defunct Tonopah & Tidewater Railroad; owner, Sierra Talc Company, Ferris Booth, president; Franklin Booth, secretary and manager; Don Kempher, superintendent, 333 West Second street, Los Angeles.

The present operators are confining their work to the south end of the deposit. Here the footwall of the talc is a dolomitic limestone and the hanging wall is diorite. The strike is east, dip about 25° N. In thickness it varies up to 40 feet and will probably average 12 feet or more.

It has been stoped along a length of 300 feet. The talc is white and of good grade.

Development here consists of a 60-foot vertical shaft with drifts 100 feet west and 200 feet east, at the bottom. From this level 2 winzes 100 feet apart have been sunk on the vein 200 feet and the ore blocked out and partially stoped between them. There are two levels from each winze with a total of approximately 1800 feet of drifting. The stopes in several places are 25 feet to 30 feet wide. Some 350 feet northeast of this shaft another has been sunk 300 feet on an inclination of 20°. Four short levels, none of them over 100 feet, have been driven from the shaft. All of this work is in talc, the thickness of which has not yet been determined.

On the north end of these deposits there are extensive workings, now idle. From these workings shipments of more than 100,000 tons of talc have been made. The principal development since 1931 [15] consists of vertical shaft on No. 4 claim, 160 feet deep, with three levels. The ore developed here was 250 feet long with a thickness of 12 feet to 20 feet. At 320 feet northeast from this shaft is an incline shaft 60 feet deep from which 8000 tons were mined. The thickness of the vein here was from 8 feet to 12 feet.

Two other shafts on the Addenda claim, 1500 feet apart, were sunk to 50 feet in depth. Ore in the south shaft was 8 feet wide by 400 feet long; in the north shaft, 8 feet wide by 200 feet long. Shipments from these workings approximated 30,000 tons.

Equipment at the south end workings consists of 220-cubic foot portable compressor and gas hoist.

Shipments of 500 to 600 tons per month are made from Dunn Siding to the company's plant in Los Angeles. Eight men are employed.

Bibl.: State Mineralogist's Reports XVII, pp. 369-370; XXVII, pp. 100-104; U. S. B. M. Bull. 213, pp. 116-117.

Smith mine is in the Kingston Mountains, 15 miles southeast of Tecopa, in sec. 12 (?), T. 19 N., R. 10 E., S. B.; owner, Sierra Talc Company, Ferris Booth, president; Franklin Booth, secretary and manager; Don Kempher, superintendent, 333 West Second street, Los Angeles.

The talc occurs between dolomitic walls, strike N. 60° E., dip 25° to 65° NW. The width varies up to 20 feet, with horses of wall rock. The talc is white in color and is of excellent grade. It is used in the paint and textile industries.

Development consists of a tunnel driven southwest 600 feet. At 270 feet from the portal, a winze has been started which will be sunk to 100 feet. At 100 feet from the portal, there is a shaft sunk from the surface 40 feet to tunnel. Two stopes have been developed, one of which is 20 feet wide, worked with square sets. They are shipping 250 tons per month.

Equipment consists of a portable compressor. Five men are working.

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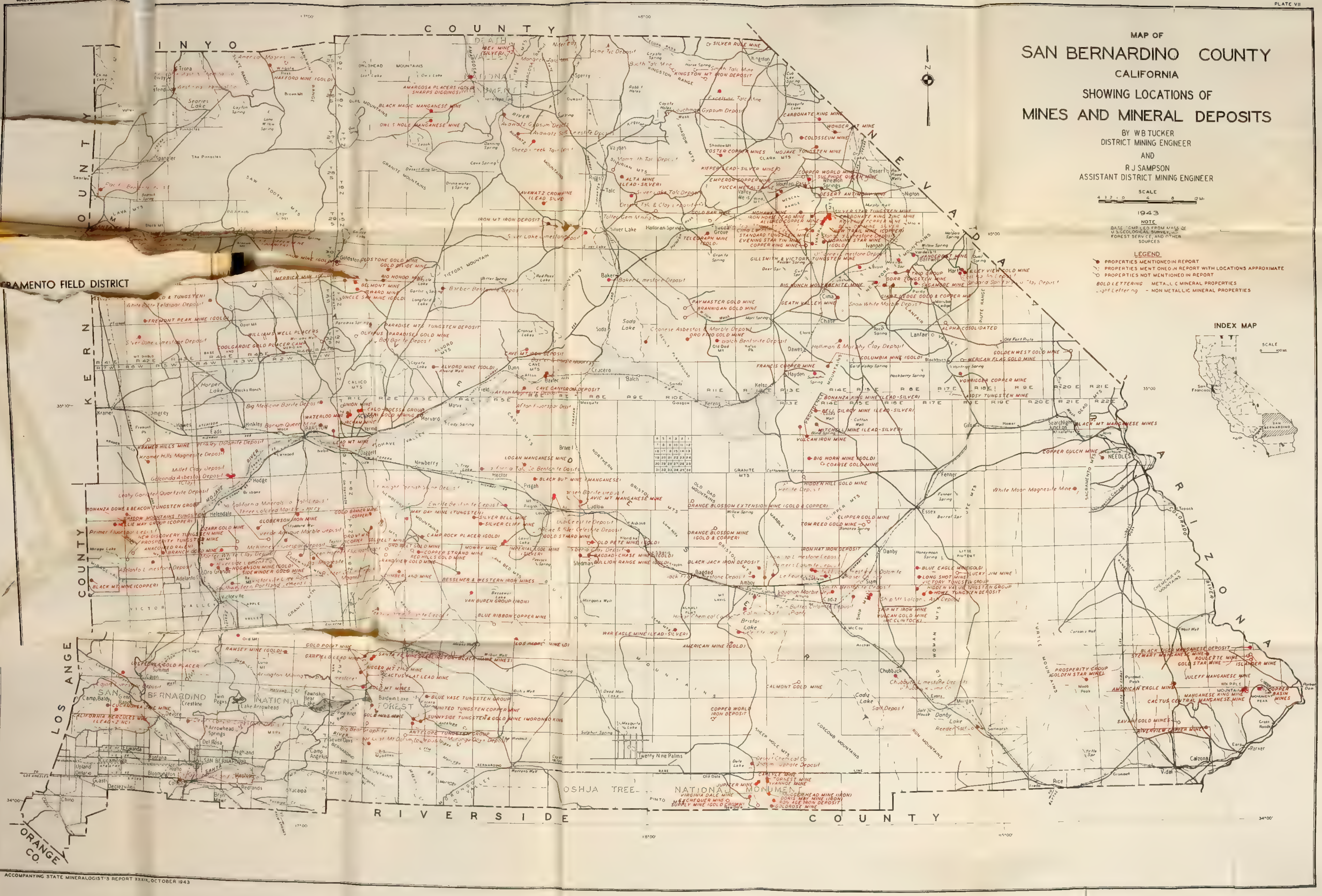
[15] Tucker, W. B., and Sampson, R. J., op. cit.

DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALO

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

PLATE VII



MAP OF
SAN BERNARDINO COUNTY
CALIFORNIA
SHOWING LOCATIONS OF
MINES AND MINERAL DEPOSITS

BY W B TUCKER
DISTRICT MINING ENGINEER
AND
R J SAMPSON
ASSISTANT DISTRICT MINING ENGINEER

SCALE
4 3 2 1 0 4 8 12 MI

1943

NOTE
BASE COMPILED FROM MAPS OF U.S. GEOLOGICAL SURVEY, U.S. FOREST SERVICE, AND OTHER SOURCES

LEGEND
● PROPERTIES MENTIONED IN REPORT
◌ PROPERTIES MENTIONED IN REPORT WITH LOCATIONS APPROXIMATE
○ PROPERTIES NOT MENTIONED IN REPORT
BOLD LETTERING - METALLIC MINERAL PROPERTIES
Light Lettering - NON METALLIC MINERAL PROPERTIES

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXIX, OCTOBER 1943

SAN BERNARDINO COUNTY MINES AND PROSPECTS

METALS

ANTIMONY

NAME OF PROPERTY	SEC	T	R	M
Desert Antimony	29	16 N	14 E	S. B

COPPER

NAME OF PROPERTY	SEC	T	R	M
Allured Copper	9	15 N	14 E	S. B
American Eagle	32	3 N	24 E	S. B.
Black Mountain	19	8 N.	7 W	S. B.
Blue Ribbon *	4	4 N.	5 E	S. B.
Copper Basin Mines	3, 4	2 N	26 E	S. B.
Copper Gulch	28	9 N	22 E	S B
Copper King *	36	15 N.	13 E	S B
Copper Strand	9	6 N	3 E	S. B.
Copper World	1	16 N	13 E	S. B
Dixie Copper *	33	29 S.	45 E.	M. D.
Emperor *	3	16 N.	13 E	S. B
Foster Mines	15	17 N	11 E.	S B
Francis Copper	7	11 N	14 E	S B
Giant Ledge Gold & Copper	31	14 N	16 E	S. B.
Gold Banner	12	7 N	1 E	S B
Nellie May Group	2	7 N.	7 W.	S B
New Trail	4	15 N	14 E	S. B
Orange Blossom *	23	7 N	11 E	S B
Orange Blossom Extension *	30	8 N	11 E	S B
Ord Mountain	12, 13, 24	7 N	1 E.	S. B.
Revenue	4	15 N	14 E	S B
Riverview	1	1 N	24 E	S B
Sagamore	35	14 N.	16 E	S B
Trio group (see under Gold)				
Vontrigger copper mine (see under Gold)				

GOLD

NAME OF PROPERTY	SEC	T	R	M
Alpha Consolidated *	33	13 N	17 E	S. B.
Alvord	1, 2, 12	11 N	3 E	S. B
Amargosa Gold Placers	11, 14, 23, 24, 25	19 N	4 E	S B
American	19	4 N	12 E	S B
American Flag *	35, 36	12 N	17 E	S B
Bagdad-Chase Mines	7, 8	6 N.	8 E	S B
Belmont	35	14 N.	1 E	S B.
Big Four	19	14 N.	1 E	S B.
Big Horn	20	9 N.	14 E	S. B.
Blue Eagle	19	6 N	17 E	S. B.
Branch Gold *	31?	7 N	3 W.	S. B
Brannigan *	28	12 N.	10 E.	S B
Bullion Range Co., Inc	7	6 N	5 E	S B
Calmont * (Approx.)	24	3 N	13 E	S B.
Camp Rock Placer	28	7 N.	3 E	S. B.
Carlyle	11	1 S.	12 E	S. B.
Clipper *	13	7 N	15 E	S. B
Coarse Gold	27?	9 N.	14 E.	S B
Colosseum	10, 14	17 N.	13 E	S B
Columbia	3	11 N.	14 E.	S B
Coolgardie Gold Placer Camp *	29	32 S	46 E	M D
Cumberland	25, 26	6 N	2 E	S B
Exchequer *	25	1 S	11 E	S B
Fremont Peak	33, 34	31 S.	42 E	M D
Gold Bar *	9	15 N	11 E	S B
Gold Belt	29	7 N	2 E	S B
Gold Crown	21, 22, 27, 28	1 S.	12 E	S B
Gold Divide	22	14 N.	2 E	S B
Gold Hill	17	2 N	2 E	S B
Gold Mountain	36	3 N	1 E	S B.
Gold Point	1	3 N	1 E	S B
Gold Rose	32	1 S	13 E	S B
Gold Standard *	32	7 N	8 E	S B
Gold Star *	8	3 N	26 E	S B
Golden West *	26	12 N	20 E	S B
Goldstone *	18?	14 N.	1 E	S B
Grand View *	9	6 N	2 E	S B
Hafford	14, 15, 22, 23	25 S	45 E.	M D
Hidden Hill *	4	8 N	14 E	S. B
Hoganson	14	6 N	4 W	S B
Islander *	5	3 N.	26 E	S B
Ivanhoe	7	1 S	13 E.	S B
Jupiter	11	1 S	12 E	S B
Kramer Hills *	36	10 N	8 W	S. B
Long Shot	30, 32	6 N	17 E	S. B
Los Flores Gold Placers *	31, 32	3 N	4 W	S B
Los Padre	18	4 N	8 E	S B
Lucky Jim *	30	6 N	18 E	S B
Merrick	35	14 N	1 E	S B
Morning Star	27, 28, 33, 34	15 N	14 E.	S B
Old Pete	33	7 N	8 E	S B
Olympus *	13	12 N	1 E	S. B
Ord Belt *	4, 10	6 N.	2 E	S B
Oro Fino	14	12 N.	10 E	S B
Ozark *	30?	7 N	1 W	S B
Paymaster *	23	13 N	10 E	S B
Prosperity Group of Mines	23	3 N	21 E	S. B
Ramsey	2, 3	3 N	2 W	S B
Red Hills *	8	6 N.	3 E	S B.
Reward	2, 3, 10, 11	13 N.	1 E	S. B
Rio Hondo	33	14 N.	2 E	S. B
Roulette	8?	3 N	26 E	S. B
Santa Fe Mines	5, 8, 9, 16, 17	3 N	2 E	S B
Savahl *	32	2 N	24 E	S B
Sidewinder *	3, 4	6 N.	2 W	S B
Sulphide Queen	12, 13	16 N	13 E	S. B.
Telegraph Mines	16, 17, 20	15 N	11 E	S B
Tom Reed *	14	7 N	15 E	S B
Top Nest	7	1 S.	13 E	S B.
Trio Group	21, 22	14 N	16 E	S B
Uncle Sam	33	14 N	1 E	S B
Valley View	24	14 N	17 E	S B
Vanderbilt	3	14 N	16 E	S B
Virginia Dale *	35	1 S	12 E	S. B
Vontrigger	10, 11, 15	11 N	17 E.	S B
Vulcan	11	5 N	15 E	S B
Williams Well Placers *	20	32 S	47 E	M D

IRON

NAME OF PROPERTY	SEC	T	R	M
Bessemer & Western Iron Mines	27, 28	6 N.	4 E.	S. B
Black Jack	24	6 N	12 E	S B.
Cave Canyon	12	11 N	6 E	S. B.
Cave Mountain	20	12 N.	6 E.	S. B.
Copper World	22?	2 N.	11 E	S B.
Dorris May	19	1 S.	13 E.	S. B.
Globerson	15	7 N	3 W.	S. B.
Iron Age	29	1 S.	13 E	S B.
Iron Hat	21	6 N	14 E	S. B.
Iron Mountain	11, 12, 13, 14	15 N.	6 E	S. B.
Kingston Mountain		19 N	11 E	S. B.
Nigger Head	21?	1 S.	13 E	S. B.
Ship Mountain	11	5 N	15 E.	S. B.
Van Buren Group	12 7	5 N 5 N	4 E 5 E	S. B. S B.
Vulcan	25	10 N	13 E	S. B.

LEAD-SILVER AND ZINC

NAME OF PROPERTY	SEC	T	R	M
Alta	6	16 N	9 E	S B.
Anaco	30, 31	7 N	5 W.	S. B.
Avawatz Crown	26	16 N	6 E.	S. B.
Bell Gilroy	9	10 N	14 E	S. B
Bonanza King	31 6	10 N 9 N	14 E 14 E	S. B S B.
Bullion	3	15 N	14 E	S. B.
Burcham	16, 21	10 N	1 E	S B.
Cactus Flat	19	3 N	2 E	S. B
Calico-Odessa Group	10, 11, 14, 15, 23	10 N	1 E	S. B.
California-Hercules	29, 32?	2 N	6 W	S B.
Carbonate King	31	16 N.	14 E	S B
Carbonate King Zinc	4 32	15 N 16 N	14 E. 14 E	S. B. S B
Cucamonga Zinc	25	2 N	7 W.	S B
Death Valley	11	13 N	14 E	S B.
Garfield	12?	3 N.	1 E.	S. B.
Gold Hill	no location			
Ibex		19 N	5 E.	S B.
Imperial Lode	35	7 N	5 E.	S. B
Iron Horse	35	16 N	13 E	S B
Kelly Gold and Silver Mines	6	30 S	41 E	M D
Kisper Lead-Silver		17 N	13 E	S B
Lead Mountain	36	10 N	1 W	S B
Mitchell	21	10 N	14 E.	S. B.
Mohawk	18	16 N.	13 E.	S. B.
Mowry	35	7 N	5 E	S B
Nigger Mountain	22, 23, 27	3 N	1 E	S B
Santa Fe	6	30 S	41 E	M D
Silver Bell	12	7 N	4 E	S B
Silver Cliff	18	7 N	5 E	S. B
Silver Rule		19 N.	11 E	S. B
Union	18	10 N.	1 E	S B
War Eagle	2, 3	4 N	10 E	S B
Waterloo	16	10 N.	1 E	S. B
Wonder Mountain Mines Inc	15	17 N	14 E	S. B
Yucca Metals	17	16 N	13 E	S B
Zenda Gold Mining Co	15, 22	10 N	1 E	S. B.

MANGANESE

NAME OF PROPERTY	SEC	T	R	M
Black Butte	10	8 N.	6 E	S. B
Black Magic	10	18 N	3 E	S. B
Black Mountain	30?	10 N	22 E	S B
Black Tiger	32	4 N.	26 E	S B
Cactus Central	8	2 N	26 E	S. B.
Juleff		2 N	26 E	S B
Lavic Mountain	22, 23	8 N	7 E	S. B
Logan	32	9 N	6 E	S B
Manganese King	1 6	2 N 2 N	25 E 26 E	S B. S B
Owl's Hole	22	18 N	3 E	S. B.
Stewart	5	3 N	25 E	S. B

MOLYBDENUM

NAME OF PROPERTY	SEC	T	R	M
Big Hunch	35	14 N	15 E	S. B

TIN

NAME OF PROPERTY	SEC	T	R	M
Evening Star	30	15 N	14 E	S B

TUNGSTEN

NAME OF PROPERTY	SEC	T	R	M
American *	18	30 S	41 E	M D
Antelope	33	2 N	3 E	S B
Argosy		11 N	17 E	S B
Atolia Mining Co.	19, 20	30 S	41 E	M D
Atolia Rand Placer *	30	30 S	41 E	M D
Atolia Tung-Sun Placer Mining Co	7	30 S	41 E	M D
Black Hawk *	19, 30	30 S.	41 E	M D
Blue Vase	2	2 N	3 E	S. B
Bonanza Dome & Beacon Group	6 12	7 N 8 N	6 W 6 W	S B S B
Brooke see Big Hunch, under Molybdenum				
Dorr	36	14 N	15 E	S B
Gillamith & Victory	17	14 N	15 E	S B
Gold Basin	7	30 S	41 E	M D
Hidden Value & Victory	5, 8	5 N	17 E	S B
Howe	9	5 N	17 E	S. B
May Day	7	7 N	3 E	S B
Mojave	19	17 N	14 E	S B
New Discovery *	6	6 N	6 W	S B
Osdick Group	20, 21	30 S.	41 E	M D.
Paradise Mountains	6, 7	12 N	2 E	S B
Prosperity *	32	7 N	8 W	S. B
Shadow Mountain	30, 31	8 N	6 W	S B
Silver Star	6, 7	15 N	14 E	S. B
Spud Patch	parts of 20, 21	30 S	41 E	M D
Standard	18	15 N	14 E	S B
Sunnyside	27	2 N	3 E	S. B
United	28	2 N	3 E	S B

NONMETALLICS

ASBESTOS

NAME OF PROPERTY	SEC	T	R	M
Cronese	14	12 N	9 E	S B
Golconda	36	9 N	4 W	S B

BARITE

NAME OF PROPERTY	SEC	T	R	M
Ball	20?	12 N	2 E	S B
Barium Queen	22, 27	10 N	1 W	S. B
Big Medicine	3	10 N	1 W	S B
Hansen	30	8 N	8 E	S B

BENTONITE

NAME OF PROPERTY	SEC	T	R	M
Balch	10	12 N	11 E	S B
Barber	6	13 N	4 E	S B
California Talc Co.	31 22, 23, 24, 26, 27	8 N 8 N	5 E 5 E	S B S B
Ewrite	35	8 N	5 E	S. B
Pacific	29, 30?	28 S	41 E	M D
Smith	26?	6 N	14 E	S B

CLAY

NAME OF PROPERTY	SEC	T	R	M
Coore	13, 24	14 N	17 E	S B
Golconda	36	9 N	4 W	S B
Holliman & Murphy	14	12 N	14 E	S. B
Le Feure	26	6 N	14 E	S. B
Marter White	34, 35	7 N	4 W	S. B
Millet	31	9 N	3 W	S B
Siberia	4	6 N	9 E	S B
Standard Sanitary Co	24	14 N	17 E	S. B

FELDSPAR

NAME OF PROPERTY	SEC	T	R	M
White Butte	16	31 S	44 E	M D

FLUORSPAR

NAME OF PROPERTY	SEC	T	R	M
Afton	7	10 N.	6 E	S B
Green Hornet	7, 8	6 N	1 W	S B
McKinney	1	6 N	1 W	S B
Primer	20?	7 N	6 W	S B

GEMS

NAME OF PROPERTY	SEC	T	R	M
Morongo Onyx *	8	1 N	3 E	S B
Toltec Gem Mining Co *	36	16 N	9 E	S B

GRANITE

NAME OF PROPERTY	SEC	T	R	M
Texas Quarries	29	5 N	2 E	S B

GRAPHITE

NAME OF PROPERTY	SEC	T	R	M
Big Bear *	31	2 N	2 E	S. B

GYPSUM

NAME OF PROPERTY	SEC	T	R	M
Avawatz	13, 16, 21, 22, 27, 36	18 N	5 E	S B
Couchman		18 N	10 E	S B

LIMESTONE

NAME OF PROPERTY	SEC	T	R	M
Adelanto	2	6 N	6 W	S. B
Arlington Mining Corp	5, 8, 9 16, 17	3 N	2 E	S B
Baker	26?	14 N	8 E	S B
Baxter & Ballardie Quarry	12	11 N	6 E	S B
Cajon	27, 32	3 N	8 W	S B
California Portland Cement Co	19, 30	1 S	4 W	S B
Chalmers Dolomite	29	6 N	13 E	S B
Chubbuck Limestone & Dolomite Deposits	17, 20, 21	6 N	14 E	S B
Chubbuck Lime Co.	10, 11, 15, 16, 21, 22	3 N	16 E	S B
Cima	12, 13, 24 7	15 N 15 N	13 E 14 E	S B S B

LIMESTONE—Continued

NAME OF PROPERTY	SEC	T	R	M
Devil's Canyon	5	1 N	4 W	S. B
Hesperia Dolomite	27, 28, 33	4 N	3 W	S B.
Hinkley Dolomite	11, 12	9 N	4 W	S B
Jack Frost	26	6 N	12 E	S B.
O'Connell	8, 9	14 N	16 E	S B.
Richter Dolomite	15	6 N	1 W	S. B.
Riverside Cement Company's Quarry & Plant	9, 16, 17	6 N	4 W	S. B.
Silver Dome	9,	32 S	42 E	M. D
Silver Lake	18, 19	15 N.	8 E	S. B
Snowcap	30	6 N	13 E	S B
Snow White Marble	20	14 N	16 E	S B.
Southwestern Portland Cement Company's Quarries & Plant	5, 6 11, 15, 16	6 N 6 N	2 W 4 W	S. B. S. B
Standard	20?	15 N	16 E	S. B.
Sugar Loaf Mountain Dolomite	17	1 N	2 E	S. B
Three Colored Marble	2	7 N	2 W.	S B
Twin Buttes Dolomite	9	5 N	15 E	S B
Vaughan Marble Quarries	2, 11 22, 26, 27, 28	5 N 6 N	14 E 14 E	S. B. S. B.
Verde Antique Marble	28	7 N	2 W	S B
Victorville Lime Rock Company's Quarry	25, 36	6 N	4 W	S B

MAGNESITE

NAME OF PROPERTY	SEC	T	R	M
Afton	20	11 N	6 E	S B
Ball	2	6 N	2 W	S B
Kramer Hills	14	9 N	6 W	S B
New Trail Mining Co	4	15 N	14 E.	S B
Richter	15	6 N	1 W	S B.
White Moon	15, 22	8 N	21 E	S B

PUMICE AND VOLCANIC ASH

NAME OF PROPERTY	SEC	T	R	M
Perlite	10?	8 N	13 E	S B.
Ship Mountain	11?	5 N	15 E	S. B.

SALINES

NAME OF PROPERTY	SEC	T	R	M
American Magnesium Co	7	25 S	46 E.	M D
American Potash & Chemical Corp	17	25 S	43 E.	M D
Avawatz Salt	13, 16, 21, 22, 27	18 N	5 E	S B.
Cadiz Dry Lake Salt		2 N 3 N	15 E 15 E	S B S B.
California Rock Salt Co Plant location	11	5 N	12 E	S. B
Desert Chemical Co *	26, 27, 34	1 N	12 E	S B
Hollar Chemical Co., Inc	21, 22	5 N	12 E	S B
Reeder Salt Co	26	2 N	16 E	S. B
West End Chemical Co	5, 6	26 S	43 E	M D

SILICA

NAME OF PROPERTY	SEC	T	R	M
Emsco Quartzite	(NE of Victorville)			
Leahy Ganister	36	9 N.	4 W	S B.
McKnight	18	7 N	2 E	S B
White Cloud	35	29 S	44 E	M D

STRONTIUM

NAME OF PROPERTY	SEC	T	R	M
Avawatz Celestite	13, 16, 21, 22, 27	18 N	5 E	S. B
Bristol Lake Celestite	4, 7, 8	4 N	12 E	S. B.
DuPont Co	19, 30	8 N.	7 E	S B
Rowe & Buehler Celestite	19, 30	8 N	7 E	S B

TALC

NAME OF PROPERTY	SEC	T	R	M
Acme	4 32, 33	19 N 20 N	8 E. 8 E	S. B S B.
Booth	9?	19 N	10 E	S. B.
Desert Talc & Clay	30?	16 N	11 E	S B
Excelsior	27	16 N	11 E	S B
Mammoth *	35	17 N	8 E	S B.
Monarch		19 N.	5 E.	S B
Sheep Creek	5, 6	17 N	6 E	S B
Silver Lake	20, 21	16 N	9 E	S. B
Smith	12?	19 N	10 E	S. B.

* Not mentioned in report.

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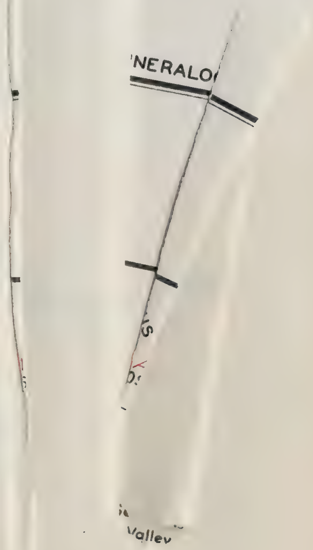
NERALO
Valley

SACRAMENTO FIELD DISTRICT

CURRENT NOTES ON ACTIVITY IN THE STRATEGIC MINERALS, SACRAMENTO FIELD DISTRICT

By CHARLES V. AVERILL *

OUTLINE OF REPORT

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AMADOR COUNTY

Copper

Copper Hill Mine. This mine, which is in secs. 34, 35, T. 8 N., R. 9 E., M. D., is owned by the Detert Estate and has recently been leased to J. P. Donovan, 3270 21st Street, San Francisco. Donovan holds a 10-year lease on about 1000 acres. Ralph Osborn of Plymouth is foreman at the mine. The shaft, known as the Jackass shaft, which is about 1200 feet west of the main shaft, has recently been cleaned out by Donovan and sunk a few feet to the 106-foot point. Donovan states that an old level existed at 97 feet but that the work was not done on the vein. The vein strikes N. 30° W. and dips 45° NE. and is about 4 feet in width. Its grade is represented by the following two samples:

Oz. Au	*Oz. Ag*	*Cu%*	*Zn%*	*Insol.%*	*Fe%*	*S%*
.10	6.9	2.8	10.4	43.2	15.5	20.0
.20	14.6	2.0	32.2	14.8	13.9	26.5

The second sample represents an 8-inch streak of high-grade zinc ore, and the first sample represents the remainder of the width of 4 feet.

Donovan states that at the main shaft a large dump contains 100,000 to 125,000 tons of a milling grade of zinc ore and he is planning to shut the mine down within the next few days (August 1943) pending the possible erection of a mill to treat both this dump ore and ore from the mine. He has made application for a Reconstruction Finance Corporation loan for such a mill. He has records of many carloads of ore shipped from this shaft to the Mountain Copper Company. These old shipments ran 10, 12, 14, and 16 percent copper and from 8 to 10 percent zinc.

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* District Mining Engineer, Sacramento Field District, California State Division of Mines. Manuscript submitted for publication December 28, 1943.

The U. S. Bureau of Mines has recently done diamond drilling at this property to prove the extension of the vein in depth.

Newton Mine. This mine is in sec. 28 (?), T. 6 N., R. 10 E., M. D., on the highway running from Ione to Jackson. It is being operated by Winston Copper Company, Subway Terminal Building, Los Angeles 13. Wayne Loel is president, and Wallace Hunt is secretary. The mine has been unwatered recently to the 380-foot level, and sampled by the Reconstruction Finance Corporation. Special arrangements have been made with the War Production Board so that 22 cents per pound is obtained for copper. The strike of the vein is N. 40° W. and the dip is 60° to 80° NE. Country rock in the vicinity is amphibolite schist. On the bottom level, at about the 380-foot point in the shaft, the vein is 2 to 3 feet wide, and 575 feet of drifting has been done on it. The part of the vein being stoped at the present time averages 4 feet in width and has a maximum width of 9 feet.

The mine was opened recently by J. H. Lester, who shipped three carloads of ore. The present operators are mining a block of ore above the 100-foot level with a crew of 40 men under H. M. Lewers of Plymouth. Production (December 1943) has amounted to 50 carloads averaging 60 tons each, from 8 to 10 percent copper. Work is proceeding on the 200 level to develop the extension of this same block that is being mined. The block is entirely to the north of the shaft. This is a heavy sulphide ore, largely pyrite, but it is darker in color than ordinary pyrite and is believed to be enriched by supergene chalcocite. Diamond drilling by the U. S. Bureau of Mines indicated a much larger block of ore than that being mined, at a depth greater than workings have reached. However, this ore is not as high in grade as the ore being mined, and a decision as to whether it will be developed must wait on a decision of the Government on the need for copper.

Freight charges on this ore are as follows: 60 cents per ton trucking charge to a railroad siding between the mine and Ione, plus $5.75 per ton railroad freight to the smelter, plus 3 percent government tax on both of these items. The amount actually received from the smelter for copper amounts to 9.067 cents per pound after the freight to the refinery and the refining costs are deducted. The bonus of 10 cents per pound received from the Government is responsible for a profit to the operators. Treatment charge at the smelter is roughly $3 per ton.

CALAVERAS COUNTY

Copper-Zinc

Penn Mine. This mine is in sec. 33, T. 5 N., R. 10 E., and secs. 3, 4, T. 4 N., R. 10 E., M. D., at Campo Seco. No. 2 and No. 3 shafts of the Penn mine are being unwatered by a partnership of H. G. Miller and George W. Clemson of Chinese Camp. This same partnership owns the Eagle Shawmut Mining Company. D. C. Peacock is manager, and Roger Peet is superintendent. These two shafts are about 1200 feet apart on a line running N. 22° W. Unwatering is being accomplished by air-lifts for which wooden pipe of an inside diameter of 5 inches is being used. In this way trouble with the acid water eating pumps is avoided. The unwatering has proceeded in both shafts to about the 500-foot level (November 1943). The operators expect to mine ore on the 6, 8, 10, and 11th levels. They are remodeling the Eagle Shawmut mill to a capacity

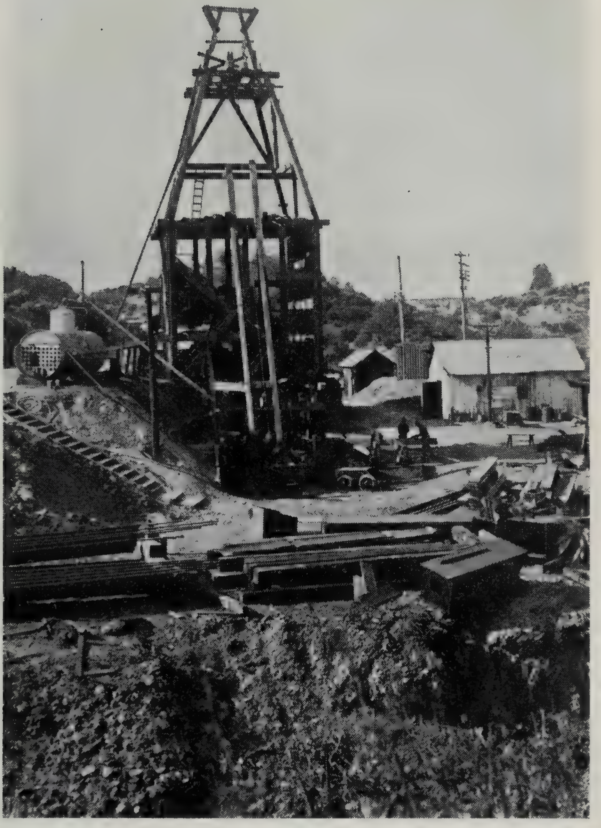

FIG. 1. Penn Mine, Calaveras County, Shaft No. 2.

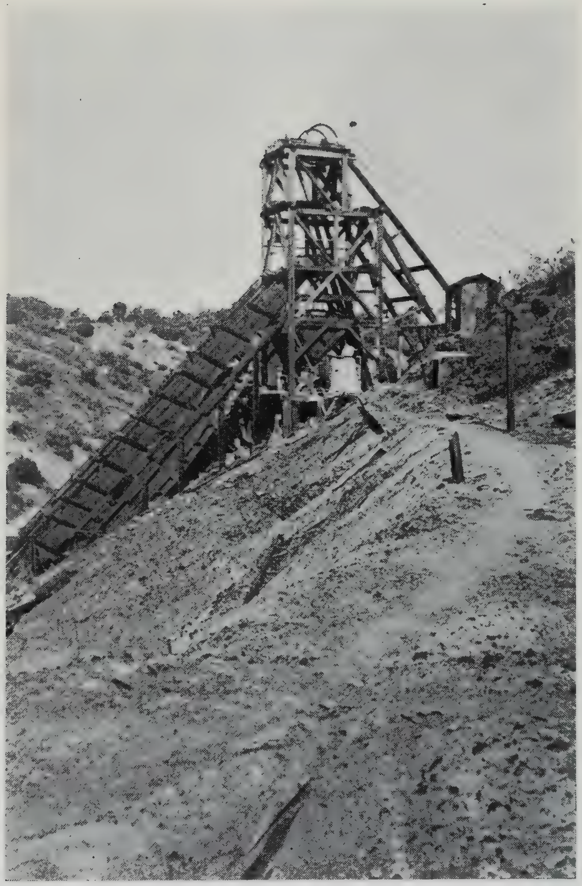

FIG. 2. Penn Mine, Calaveras County, Shaft No. 3.

of 500 tons per day on this type of ore, and the amount of ore milled per day will be as near that much as the mine is able to produce. Treatment will be by selective flotation producing three products, a copper concentrate, a zinc concentrate, and pyrite, which will probably carry some gold and silver. The No. 2 shaft has been equipped with a new headframe, and an ore bin of 350 tons capacity is being built into this headframe. This shaft is equipped with a single-drum hoist driven by a 150-horsepower electric motor, and the No. 3 shaft is equipped with a double-drum hoist.

Further details of this mine are given by Julihn and Horton[1]. A geological map shows that the No. 2 shaft is on a west vein striking N. 40° W. and dipping 70° E. No. 3 shaft is on an east vein with a similar strike and dip. Details of sampling are given showing that the No. 3 shaft in March 1926 contained 32,713 tons of developed ore between the 1900- and 2700-foot levels, containing 0.061 ounce of gold, 2.14 ounces of silver, 5.58 percent copper, and 5.88 percent zinc. No. 2 shaft is stated to contain developed ore amounting to 68,643 tons averaging 0.071 ounce of gold, 3.06 ounces of silver, 3.20 percent copper, and 11.01 percent zinc. Two blocks of probable ore are also mentioned, one of 40,000 tons and one of 35,000 tons. The deepest level of this shaft was the 1100 at that time. A connection is supposed to exist on the 1400-foot level.

Present operators are not planning to go deeper than the 1400-foot level with their operations. Ore at the No. 2 shaft is all south of that shaft, whereas ore developed at the No. 3 shaft is north of that shaft. The 1200 feet between is virgin ground and may be prospected.

COLUSA COUNTY

Manganese

Black Diamond Manganese Mine. A. R. Bickford, 229 Clinton Avenue, Roseville, holds seven claims in secs. 26, 35, T. 18 N., R. 7 W., M. D., 4½ miles west of Stonyford. The deposit of manganese ore is half a mile north of Big Stony Creek on both sides of a small tributary. Ore has been exposed intermittently for 100 feet along this tributary, which runs south. Bulldozer cuts have been made for this distance along both sides of the creek for a total width of about 100 feet divided into several benches. Black oxides of manganese occur in a series of cherts and sandstone, which appear to strike to the north and dip to the east, but they are much folded and faulted. Bickford thinks that the strike of the manganese ore is N. 55° W., but this seems uncertain. The ore is much contaminated with chert, and careful hand-sorting is needed to produce a commercial grade. C. M. Syar of Vallejo is leasing the deposit and has produced 85 tons of ore running 39.7 percent manganese. Three other lenses of manganese crop out within 100 to 200 yards north and west of these bulldozer cuts. A mile and a half of new road has been built to connect the deposit with the county road. Big Stony Creek must be forded, so this is a summer road only.

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[1] Julihn, C. E.,, and Horton, F. W., Mines of the southern Mother Lode region, part I—Calaveras County: U. S. Bur. Mines Bull. 413, pp. 112-116, 1938.

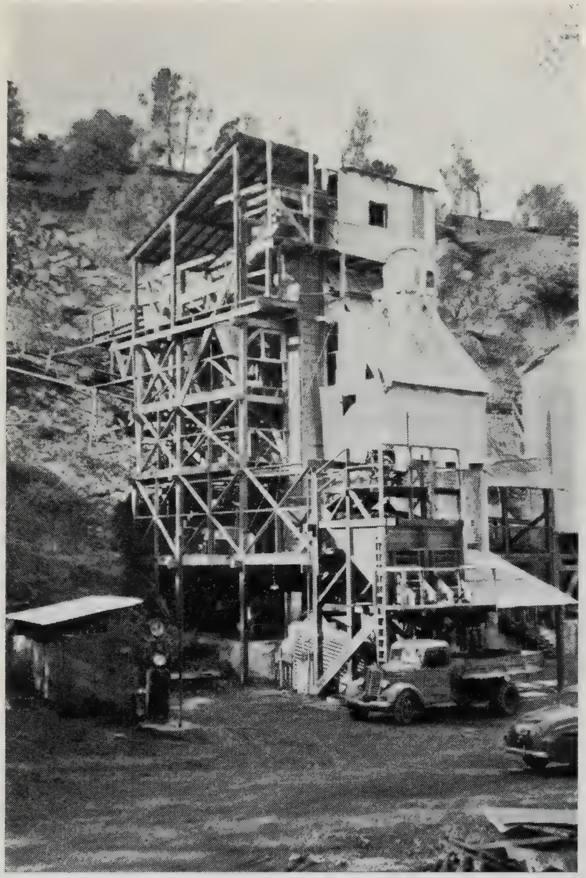

FIG. 3. Taylor Chrome Mill, El Dorado County.

EL DORADO COUNTY

Chromium

Taylor Chrome Mine. Workings of this mine on the Darrington ranch and plans for a new mill were described in the California Journal of Mines and Geology for July 1943,[1] The new mill in sec. 15, T. 11 N., R. 8 E., M.D., had been running for a few days when visited November 24, 1943, and the first concentrates had been produced. The mill consists of an ore-bin, 8-inch by 15-inch crusher, Hendy ball mill, 5 feet by 6 feet, driven by 60-horsepower motor, bucket-elevator to a two-deck vibrating screen, cones for dewatering, Fahrenwald hydraulic sizer delivering four different sizes to four tables of both Wilfley and Deister make. The classifier is designed to deliver six different sizes, and plans call for the addition of two more tables. Below the four rougher tables are a cleaner table and a rake-classifier for dewatering the concentrate. The mill contains two Pan-American jigs each about 40 inches square, but these are not yet in use. Ore for the mill is now coming from the Darrington property in the southern part of the same township.

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[1] Averill, C. V., Current notes on activity in the strategic minerals, Sacramento Field District: California Div. Mines, Rept. 39, pp. 317-318, 1943.

Development work is proceeding at the Dobbas property about three-fourths of a mile south of the mill. An adit runs S. 75° W. for 165 feet, where drifts have been started. The adit is being continued at a point 100 feet beyond this intersection, and plans call for driving it an additional 300 feet. A drift runs S. 11° E. and is being continued at the 90-foot point. Another drift running N. 10° W. is being cleaned out near the adit. Apparently an old drift had caved for a length of about 20 feet here. In the main adit beyond the drifts, at a distance of 35 feet, is a raise to the surface. The raise connects with the bottom of an old open pit about 50 feet by 20 feet by 20 feet deep that must have supplied ore to an old mill on this property during the war of 1914-18 (Placer Chrome Co. ?). The ridge rises steeply to the west of this pit and a milling grade of chrome ore is seen at several points ranging up to 300 feet higher in elevation. The main adit is designed to reach points under some of these. Equipment includes a portable-type compressor and an ore-bin.

GLENN COUNTY

Chromium

Chrome King. This property comprises the Chrome King No. 1, No. 2, and No. 3, three unpatented claims in sec. 19, T. 19 N., R. 6 W., M. D., 12 miles southwest of the town of Elk Creek. They are held by A. R. Bickford, 229 Clinton Avenue, Roseville.

This deposit of chrome ore in serpentine is 1½ miles southwest of the Chas. Jameson homestead on the south slope of Salt Creek. A circular pit about 10 feet in diameter and 8 feet deep exposes chrome ore on all sides estimated to run roughly 25 percent Cr_2O_3. One carload of 45 percent chrome ore is stated to have been shipped from this pit during the war of 1914-18. Recently an open cut and tunnel have been driven at an elevation 15 feet lower than this pit in a direction S. 80° W. for 40 feet. At the face of this a hole has been made into the circular pit above, but this was full of low-grade ore at the time of our visit. At about the 20-foot point in the cut, a drift has been run for 20 feet in the direction N. 50° W. A small lens of high-grade chrome ore 1 foot in width is exposed in the top of this drift. About 2 tons of chrome ore of shipping grade is on the dump. Since the property was visited in September 1943, Bickford has informed us that he has found a lens of chrome ore of good grade by extending the upper pit, and that he has started to ship the ore.

Manganese

Black Diamond. This property is in secs. 14, 23, T. 18 N., R. 7 W., M. D. It is now held by E. J. Hansen, Apt. 2 C, 461 South 20th Street, Richmond, California, and two partners, who have six claims. The mine is about 1½ miles northeast of A. R. Bickford's Black Diamond property in Colusa County, and according to Bickford, some manganese ore was shipped from it in the summer of 1943.

Brown Property. Alex Brown Company, Walnut Grove, holds hundreds of acres of agricultural patents in sec. 36, T. 19 N., R. 7 W., sec. 6, T. 18 N., R. 6 W., and sec. 1, T. 18 N., R. 7 W., M. D. The property is 40 miles by county road from Willows via Fruto, plus 4 miles of private road. Manganese and iron oxides occur in a series of cherts, slates and sandstone, probably Franciscan. Some recent prospecting has been done here with a bulldozer by Carrol Skaggs, Cottonwood, Shasta County, and H. D. Bruce, Anderson, Shasta County. Reports indicate that several carloads of manganese ore were produced here in 1943, but the property was idle in September 1943.

NEVADA COUNTY

Magnesite

Victory Mine. Victor Buck, North Bloomfield, has made a new discovery of magnesite in serpentine in sec. 14, T. 18 N., R. 10 E., M. D., 20 miles by road from Nevada City. The truck route would be about 32 miles. The elevation at the deposit is 5000 feet. He holds 40 acres as two mining claims, Victory Lode and Victory Extension. He has exposed a width of 12 feet in a trench 14 feet by 8 feet by 2 feet deep. The strike is N. 20° W. and the dip is not well exposed but is probably about vertical. At a distance of 80 feet to the north is another trench 75 feet long, which exposes magnesite from a foot to several feet wide. Buck states that he exposed the magnesite for a wdith of 4 feet in the south end of this trench, but this width was not exposed at the time of our visit because of sloughing of surface material covering the west wall. A few hundred yards of new road is needed, but this could be built easily with a bulldozer.

PLACER COUNTY

Copper-Gold

Lakeview Mine. This property is owned by A. C. Shock and is operated by Lewis F. Johnson, Auburn, California. It is in the Butcher Ranch district, sec. 32, T. 13 N., R. 9 E., M. D., 6 miles east of Auburn on the Forest Hill road and comprises five unpatented claims. In a 50-foot shaft partly vertical and partly inclined, an irregular body of ore has been found that strikes northeast and dips 60° southeast. It is from 3 feet to 6 feet wide and appears to be about half pyrite and half quartz. It is said to carry some copper and a substantial quantity of gold. Open cuts have been run in the vicinity for mining gold. The hillside is steep below the shaft, and at an elevation 130 feet lower an adit has been started to search for the continuation in depth of the orebody exposed in the shaft. It had been run 217 feet in August 1943 in a southeasterly direction in greenstone. This work is on the Hidden Tunnel claim. Two men were at work.

Copper-Zinc

Valley View Mine. Property of 90 acres at this mine was leased in 1943 by Judge J. B. Landis to Goodwin M. Trent of Auburn. It is in sec. 18, T. 13 N., R. 7 E., sec. 13, T. 13 N., R. 6 E., and sec. 24, T. 13 N., R. 6 E., M. D., 6 miles north of Lincoln. A hoist driven by gasoline automobile engine, headframe, and portable-type compressor were set up at the collar of a three-compartment vertical shaft. Some work had been done toward cleaning out this shaft, but the property was idle at the time of our visit early in August 1943.

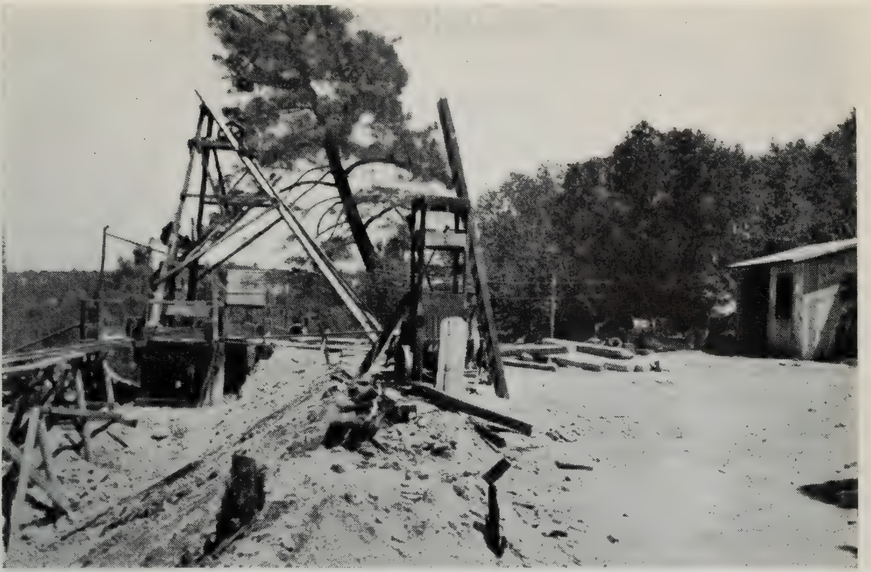

FIG. 4. Valley View Mine, Placer County.

About 200 feet southeast of this main shaft is an open cut in a decomposed schist, and some work has been done in adits from the face of the cut. In the cut, the schist strikes N. 48° W. and dips 76° NE. Just to the northwest of the three-compartment shaft is a glory hole 50 feet in diameter and 30 deep. A second shaft goes down in the bottom of this but it is caved to within 10 feet of the bottom of the glory hole. The distance between these two shafts is less than 100 feet. Between the three-compartment shaft and the edge of the glory hole, gossan crops out for a width of about 8 feet. A basic dike (gabbro?) crops out to the south of the three-compartment shaft. About 100 feet northwest of the glory hole, and 20 feet lower in elevation, is an old adit level that evidently supplied ore for a small mill at one time. Pyrite concentrate amounting to about 100 tons is piled near the site of this old mill. Still farther to the northwest, at a distance of roughly 100 feet from this adit level, is an abandoned vertical shaft with water standing to within 25 feet of the surface. As the collar of this shaft is higher than the adit, this water level is probably the same as that seen one or two feet below the adit level. All dumps show sulphide ore, but most of the sulphide is pyrite. Small dumps near the three-compartment shaft show pyrite, chalcopyrite, and sphalerite.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins *

In This Issue

In this October 1943 issue of the CALIFORNIA JOURNAL OF MINES AND GEOLOGY is published a *Geologic Map of a Portion of the Foothill Copper Belt, Calaveras County, California,* by the Stanford Geological Survey. There is no report accompanying the map. It has been contributed by Dr. Ben M. Page who makes the following statement:

"The map of a portion of the foothill copper belt prepared by the Stanford Geological Survey is mainly the work of students. While considerable care was exercised, the project was carried out without benefit of petrography. Since felsitic dikes in the area somewhat resemble silicified tuffs or perhaps even flows within the Amador series, the boundaries of some of the dikes may not be correctly depicted. However, the general geologic relations are indicated by the map."

The area mapped is 4 miles long by 1 mile wide. The scale of original sheet, 1 inch equals 400 feet, has been given reduction to 1 inch equals 800 feet. The map is of a mineralized belt and includes several mining properties principally of copper, copper-zinc, and gold. It extends from the Star Excelsior and Collier mines on the southeast to the Quail Hill mine on the northwest, including also the Little Quail Hill, Napoleon, and Gopher Hill mines. The mapping was done with plane-table during the summer of 1943 by a class of Stanford University students in geology under the direction of Professor Page. The index map shown in the margin of the main map indicates the position of the area as it lies west of the Mother Lode belt.

In forthcoming publications, the Division of Mines plans to issue other reports on the copper deposits of California, including a state-wide map of the copper deposits, as has been done in the case of Economic Mineral Maps of California:

No. 1—Quicksilver
No. 2—Oil and Gas
No. 3—Chromite
No. 4—Tungsten
No. 5—Manganese

The geologic map by Page and his students thus represents part of a larger project. Since the map was ready for publication, however, the Division of Mines deemed it advisable to make it available to the public instead of waiting until the entire project was completed.

In Preparation

Since 1942 the United States Geological Survey has been making a detailed examination of the individual copper mines and mining districts of the entire Foothill Copper Belt. Dr. George Heyl has been in charge

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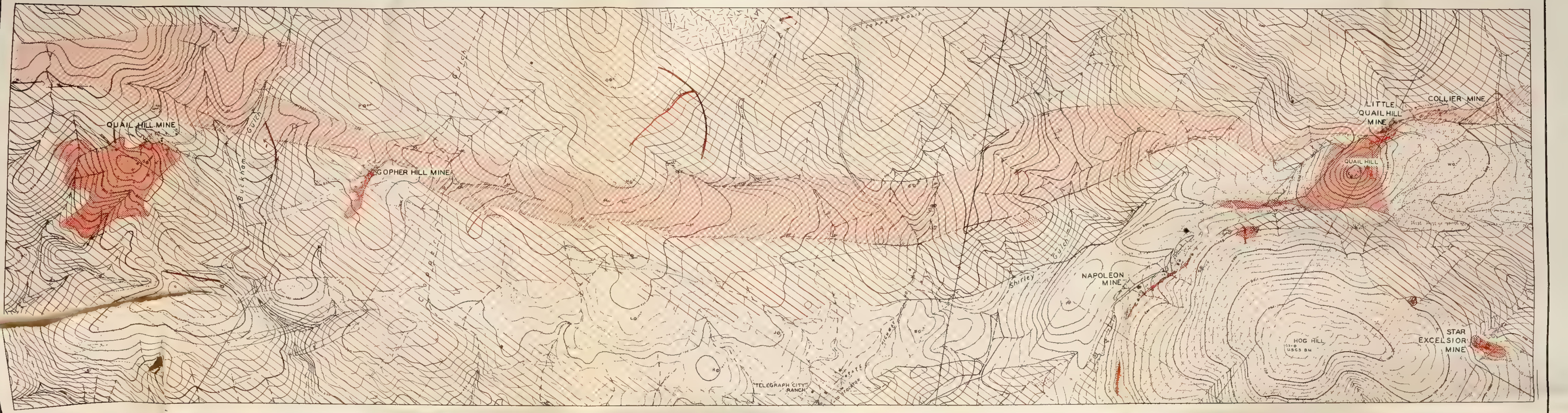
* Chief Geologist, State Division of Mines.

DIVISION OF MINES
WALTER W BRADLEY STATE MINERALOGIST
OLAF P JENKINS, CHIEF GEOLOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

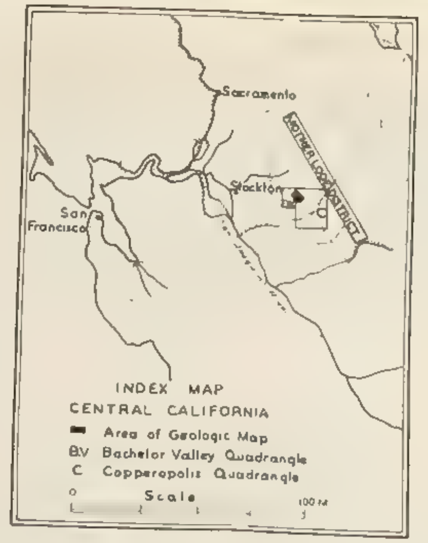
PLATE VIII



TO COPPEROPOLIS
QUAIL HILL MINE
Buckhorn Gulch
GOPHER HILL MINE
LITTLE QUAIL HILL MINE
COLLIER MINE
QUAIL HILL
NAPOLEON MINE
Shirley Gulch
HOG HILL
USGS BM
STAR EXCELSIOR MINE
TELEGRAPH CITY RANCH
STATE HIGHWAY
TO STOCKTON

CONTOURS	▨
DRAINAGE	
SURVEY STATION	⊙
ROAD paved & unpaved	
FENCE	
POWER LINE	
BUILDING	■

SHAFT	▪
DUMP	
ADIT	⊢
PROSPECT PIT	×
LARGER EXCAVATION	○
CONTACT definite to vague	
DIP & STRIKE of bedding & foliation	



Sacramento
MOTHER LODE DISTRICT
Stockton
San Francisco
BV
C

INDEX MAP
CENTRAL CALIFORNIA
■ Area of Geologic Map
BV Bachelor Valley Quadrangle
C Copperopolis Quadrangle
0 Scale 100 M

GEOLOGIC MAP
OF
A PORTION OF THE
FOOTHILL COPPER BELT
CALAVERAS COUNTY, CALIFONIA

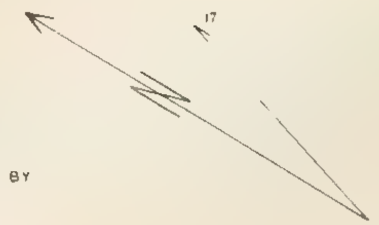
STANFORD GEOLOGICAL SURVEY

1943

SCALE
0 200 400 2400 FT

CONTOUR INTERVAL 20 FT

GEOLOGY AND TOPOGRAPHY BY
Ben M Page, director
Wm J Mapel, manager
Wm H Elson
Otto Hackel
Douglas D Hastings
Fred H Howell
Geo M MacLeod
Edward D Washburn



MINERALIZATION Gossan or abundant disseminated limonite or pyrite	⁘
PROFOUNDLY ALTERED ROCK Sericitized kaolinized, or silicified material, generally well sheared	▩
QUARTZ VEIN	⌒
RHYOLITE 'Quartz porphry' and dense siliceous felsite	☐

GRANITE Rather dark but very siliceous hornblende granite, slightly altered	▨
AMADOR SERIES STRATIFIED PORTION Dense bedded tuffs alternating with unstratified pyroclastics etc	▭
AMADOR SERIES (JURASSIC ?) Altered andesitic tuffs agglomerates, and flows, some rhyolite tuffs, diabase and greenstone, phyllite and green schist, fine diorite and other intrusives	▧

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXIX OCTOBER 1943

PHYSICAL Sciences Library

of the field work. The results of this work are to be published either by the Federal Survey or by the State Division of Mines.

A detailed geologic map of the whole of the Copperopolis quadrangle (a topographic sheet issued by the United States Geological Survey) has now been completed by Dr. N. L. Taliaferro, Professor of Geology, University of California.

The scale of the Copperopolis quadrangle which covers an area 14 by 18 miles is 1:62,500 or approximately 1 inch equals 1 mile; this is twice the scale of the older geological folios, issued by the United States Geological Survey, which cover a large part of the northern Sierra Nevada.

The new geologic map of the Copperopolis quadrangle is to be published by the Division of Mines as a colored lithograph. It will show in addition to the geology and its structure, the various mineral deposits found in the area. Accompanying the map will be a detailed geologic report prepared by Dr. Taliaferro. All of this material is contributed to the work of the Geologic Branch.

STATISTICS

CALIFORNIA MINERAL PRODUCTION FOR 1942

By Henry H. Symons *

Tabulations are presented herein showing the complete totals for all substances produced in California during the year 1942, grouped by substances and by counties. The complete detailed annual report on the mineral production of California for 1942 will be available later as Bulletin 126 of the State Division of Mines.

The total value of the mineral output of California for the year 1942 was $408,738,434, being an increase of $34,412,206 over the total of 1941 which was $374,326,228. The increase was due to stimulated output owing to war demand. There were 60 different mineral substances, exclusive of a segregation of various stones grouped under gems; all 58 counties of the State contributed to the list.

As revealed by the following, the salient features of 1942 as compared with the previous year were: such groups of mineral substances as fuels, structural materials, salines, and industrial materials showed increased total values; the metals being the only group to show a decreased value. Of the year's mineral output petroleum showed the greatest increase in value followed in turn by miscellaneous stone, cement, natural gas, chromite, tungsten ore, potash, quicksilver, soda, salt, molybdenum ore, manganese ore, dolomite, iodine, borates. Decreases were registered by gold, silver, mineral water, diatomite. The greatest annual value for their output in California was recorded for bromine, carbon dioxide, cement, dolomite, iodine, iron ore, lithium salts, molybdenum ore, natural gas, quicksilver, silica (quartz and glass sand), soapstone and talc, soda, miscellaneous stone, and tungsten ore.

Of the fuels, petroleum showed an increase in value of $23,643,376 and an increase in amount from 229,664,784 barrels to 247,491,289 barrels of crude oil. The amount of natural gas utilized increased from 378,173,737 M cubic feet, worth $21,522,445, to 413,180,942 M cubic feet, valued at $25,698,052 and was the largest annual consumption on record.

Of the metals, a record total value was reached for the annual output of iron ore, molybdenum ore, quicksilver, and tungsten ore; chromite and manganese ore output was the greatest since 1918; and lead since 1923. Nevertheless, these increased productions did not offset the decrease in the gold and silver production, and the group as a whole showed a decline in total value from $61,595,912 in 1941 to $46,185,885 in 1942.

Of the structural materials, cement increased from 19,531,608 barrels, worth $26,248,694, to 23,306,578 barrels, valued at $35,808,841; and miscellaneous stone, total value increased from $19,559,883 to $27,281,342. Both the above registered the largest annual production so far recorded in California. Brick and hollow building-tile increased in total value from $3,508,797 to $5,708,967 entirely due to the increased demand for fire brick. Building stones, such as granite, marble, and sandstone, registered a decline in total value, as also did magnesite.

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* Statistician and Curator, Division of Mines.

Of the industrial materials, the group as a whole increased in total value from $8,502,571 to $8,606,428, with such items as carbon dioxide, dolomite, lithia, silica (glass sand and quartz), sillimanite group, and soapstone and talc registering increased total values, and barites, bentonite, pottery clay, diatomite, gypsum, pumice and volcanic ash declining in value. The total value of the saline group increased from $11,927,533 to $15,645,003; increases were registered by borates, bromine, calcium chloride, iodine, potash, salt, and soda; and magnesium salts were the only substance in this classification to show a decline in output.

Distribution of the 1942 output of California by substances is shown on the following tabulation:

Substance	*Amount*	*Value*	*Number of properties*
Asbestos	8,319 lbs.	$836	3
Bentonite	7,453 tons	67,503	7
Borates	203,716 tons	4,929,553	5
Brick and hollow tile	--------	5,708,967	35
Carbon dioxide	193,143 M cu. ft.	310,000	3
Cement	23,306,578 bbls.	35,808,841	12
Clay (pottery)	622,958 tons	1,200,293	54
Copper	2,138,149 lbs.	258,716	(e)
Dolomite	142,552 tons	413,469	7
Gems	--------	570	4
Gold	847,997 fine ozs.	29,679,895	(a)
Granite	--------	186,872	11
Gypsum	425,268 tons	791,892	11
Iron ore	99,092 tons	371,562	6
Lead	10,329,176 lbs.	692,054	(e)
Limestone	474,764 tons	1,155,352	22
Magnesium salts	6,026 tons	642,680	5
Mineral water	17,559,686 gals.	567,897	36
Natural gas	413,180,942 M cu. ft.	25,698,052	(b)
Petroleum	247,491,289 bbls.	242,481,545	(b)
Pumice and volcanic ash	55,603 tons	209,539	15
Salt	672,324 tons	1,922,991	15
Sandstone	--------	8,587	8
Silica (quartz and glass sand)	193,174 tons	692,762	11
Silver	1,450,440 fine ozs.	1,031,424	(e)
Soapstone and talc	47,782 tons	545,509	12
Soda	267,723 tons	3,125,078	7
Stone, miscellaneous (c)	45,455,085 tons	27,281,342	357
Zinc	1,275,795 lbs.	118,659	(e)
Unapportioned (d)	--------	22,835,994	
Total value		$408,738,434	

(a) There were 434 lode mines and 428 placer mines, not including snipers, prospectors, and various individuals who sold small lots.

(b) There was an average of 18,033 producing wells.

(c) Includes macadam, crushed rock, ballast, rubble, rip rap, sand and gravel.

(d) Includes antimony (8), baryte (2), bituminous rock (2), bromine (3), calcium chloride (2), chromite (61), coal (1), diatomite (4), feldspar (3), iodine (2), lithium salts (1), magnesite (4), manganese ore (47), marble (f) (2), mineral paint (2), molybdenum ore (1), paving blocks (1), platinum metals (17), potash (1), pyrite (1), quicksilver (102), sillimanite group (2), slate (1), strontium (3), sulphur (1), titanium (1), tube mill pebbles (1), tungsten ore (49).

(e) Included with gold.

(f) Includes travertine.

Distribution by counties for 1942 is given in the following tabulation:

County	*Value*	*Number of mineral products*
Alameda	$6,450,260	11
Alpine	3,097	3
Amador	2,092,030	10
Butte	2,400,858	11
Calaveras	2,998,235	10
Colusa	41,710	4
Contra Costa	3,729,010	7
Del Norte	401,253	5
El Dorado	1,320,250	12
Fresno	24,790,524	14
Glenn	504,755	2
Humboldt	294,805	8
Imperial	507,130	15
Inyo	8,134,848	21
Kern	75,529,067	18
Kings	12,955,120	3
Lake	832,712	6
Lassen	35,236	3
Los Angeles	106,120,578	19
Madera	87,727	6
Marin	229,269	5
Mariposa	1,321,238	8
Mendocino	133,995	6
Merced	1,848,319	6
Modoc	53,330	4
Mono	140,764	9
Monterey	576,152	8
Napa	1,447,638	7
Nevada	5,956,238	7
Orange	27,508,497	14
Placer	1,335,034	12
Plumas	346,936	7
Riverside	7,271,099	16
Sacramento	9,884,746	10
San Benito	3,104,054	6
San Bernardino	24,638,661	33
San Diego	1,188,661	15
San Francisco	110,140	2
San Joaquin	2,079,078	9
San Luis Obispo	1,031,114	13
San Mateo	3,874,496	5
Santa Barbara	11,415,045	12
Santa Clara	9,204,217	10
Santa Cruz	3,506,972	5
Shasta	4,025,223	12
Sierra	64,895	5
Siskiyou	1,620,514	12
Solano	2,720,428	3
Sonoma	1,655,326	7
Stanislaus	1,475,362	11
Sutter	95,438	2
Tehama	47,533	2
Trinity	1,053,442	11
Tulare	168,743	8
Tuolumne	854,080	8
Ventura	23,084,373	8
Yolo	617,418	3
Yuba	3,244,771	5
Total	$408,738,434	

LABORATORY

ADDITIONS TO BULLETIN 113

By George L. Gary *

No. 129 **Analcime,** a hydrous sodium and aluminum silicate, $NaAlSi_2O_6.H_2O$, occurs in volcanic rocks in small trapezohedral crystals at Leavitt Meadows, Tuolumne County.

No. 130 **Alunite,** a basic hydrous sulfate of aluminum and potassium, $K_2Al_6(OH)_{12}(SO_4)_4$, has been found in small crystals near Railroad Flat, Calaveras County.

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* Mineral Technologist, Division of Mines.

LIBRARY

LIBRARY REPORT *

OUTLINE OF REPORT

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INTRODUCTION

The library of the Division of Mines contains more than 6,000 selected volumes on mines, mining, and allied subjects. It is also the repository for reports and bulletins of technical departments of Federal and State governments and educational institutions both domestic and foreign. Current copies of newspapers published in the mining centers of the State are also available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY AND UNITED STATES BUREAU OF MINES

The library of the Division of Mines has available for public reference the following publications of the United States Geological Survey: Annual Reports, Monographs, Professional Papers, Bulletins, Water-Supply Papers, Mineral Resources, Folios of the Geologic Atlas of the United States (broken file), Maps with Descriptive Text (broken file), Administrative Publications (broken file); and the following publications of the United States Bureau of Mines: Bulletins, Technical Papers, Economic Papers (broken file), Mineral Resources of the United States, Monographs (broken file), Reports of Investigations, Information Circulars.

Reports on California recently received from the Survey and Bureau of Mines include:

U. S. Geological Survey

Bulletins

931-Q	Quicksilver and Antimony Deposits of the Stayton District, California. 1942.
931-S	Manganese Deposits in the Paymaster Mining District, Imperial County, California. 1942.
936-D	Chromite and Quicksilver Deposits of the Del Puerto Area, Stanislaus County, California. 1942.
936-F	Quicksilver Deposits of the Parkfield District, California. 1942.
938	Bibliography of North American Geology for 1940-1941.

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* Report reprinted from July 1943 *California Journal of Mines and Geology.*

Water-Supply Papers

844 Floods of March 1938 in Southern California. 399 pp., 26 pls., 40 figs.
930 Surface Water of The Great Basin in California. 1942.
931 Surface Water of Pacific Slope Basins in California. 1942.

Topographic Maps

Chileno Canyon Quadrangle, Los Angeles County, California. 1942.
Corona and Vicinity Quadrangle, Riverside and San Bernardino Counties, California. 1942.
Eureka Quadrangle, Humboldt County, California. 1942.
Point Loma Quadrangle, San Diego County, California. 1942.

Professional Paper

197-D The Basin and Range Province in Utah, Nevada, and California. 1943.

U. S. Bureau of Mines

Bulletins

431 Mechanical Concentration of Gases.
439 Some Essential Safety Factors in Tunnelling.
451 Syllabus of Clay Testing. Part I. 1943.

Technical Paper

632 Theoretical Calculations for Explosives.

Reports of Investigation

Nos. 3693; 3696; 3700; 3704; 3706-3711 incl.; 3713.

Information Circulars

Nos. 7225; 7227; 7228; 7233; 7234; 7236; 7237; 7242.

PUBLICATIONS OF STATE SURVEYS

A broken file of mining and geological publications, issued by the organizations listed below, may be consulted in the library of the Division of Mines.

Alabama Geological Survey, University.
Alaska (Territorial Commissioner of Mines), Juneau.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Indiana Division of Geology, Indianapolis.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology and Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
New York Science Division, Albany.
North Carolina Geological and Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.

West Virginia Geological Survey, Morgantown.
Wisconsin Geological and Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

PUBLICATIONS OF FOREIGN GOVERNMENTS

Publications of the following foreign governments are received and current issues may be consulted in the library. Earlier issues of foreign-language publications have been loaned to the California Academy of Sciences in Golden Gate Park, because of the limited storage space at the Division's offices in the Ferry Building. They may, however, be consulted at the Academy.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum of Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia Geological Survey, Perth.

PUBLICATIONS OF FOREIGN AND DOMESTIC SOCIETIES AND EDUCATIONAL INSTITUTIONS

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Missouri School of Mines and Metallurgy, Rolla.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economic Paleontologists and Mineralogists, Tulsa, Oklahoma.
Southern California Academy of Sciences, Los Angeles.
Stanford University, Palo Alto, California.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

CURRENT MAGAZINES

Current issues of the technical magazines listed below are on file in the reading room of the library, and may be consulted.

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

NEWSPAPERS

Current issues of the following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Courier Free Press, Redding, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mining Press, Reno, Nevada.

Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Press-Citizen, Lone Pine, California.
Placer Herald, Auburn, California.
Placerville Times, Placerville, California.
Plumas Independent, Quincy, Caifornia.
Printer-Review, Barstow, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

NEW BOOKS

Recent accessions to the library are the following books:

T. A. RICKARD—*Retrospect* (Autobiography): McGraw-Hill Book Co., 402 pp., 1937. (Donated by Elisabeth L. Egenhoff).

NEILL C. WILSON—*Silver-Stampede* (California's Panamint Mts.): The Macmillan Company, 344 pp., 1937. (Donated by Elisabeth L. Egenhoff).

SAMUEL A. GRAHAM and EARL C. O'ROKE—*On Your Own* (How to take care of yourself in wild country. A manual for field and service men): The University of Minnesota Press. 150 pp., 1943.

EDWARD H. KRAUS, WALTER F. HUNT, and LEWIS S. RAMSDELL—*Mineralogy*. (An introduction to the study of minerals and crystals): McGraw-Hill Book Co., 638 pp., 1936.

DUNCAN A. MACINNES—*The Principles of Electrochemistry*, 478 pp. Reinhold Publishing Corp., 1939. (F. W. Bradley Memorial Book Fund).

AMERICAN SOCIETY for TESTING MATERIALS—*1942 Book of A. S. T. M. Standards*: 3 parts, about 5000 pp. Published by the Society. (F. W. Bradley Memorial Book Fund).

RAND McNALLY CO.—*World Atlas*—Premier Edition, 270 pp., more than 140 maps in color, also tables, charts and indexes. 1942.

SERVICES OF THE DIVISION OF MINES

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January 1922, and continued until March 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September 1923. For the same reason, beginning with the January 1924 issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January 1933 chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

TYPES OF REPORTS

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire State of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

Reports of District Mining Engineers

In 1919-1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the locations of the branch offices are shown on the frontispiece outline map of the State.

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

Special Articles

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Division, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of *California Journal of Mines and Geology.*

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

MAIL AND FILES

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

COMMERCIAL MINERAL NOTES

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial

minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of *California Journal of Mines and Geology,* these lists are now issued monthly in the form of a mimeographed sheet under the title of *Commercial Mineral Notes,* and sent to those on the mailing list of *California Journal of Mines and Geology.*

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-three years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for advancing the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

Write for latest revised price list.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

REPORTS

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. Price $1.50, sales tax $0.04	1.54
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913, 1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper Price $0.50, sales tax $0.01	.51
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper Price $0.50, sales tax $0.01	.51

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper—Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper—Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Geologist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper—Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper—Price $0.50, sales tax $0.01	.51
Mines and Mineral Resources of Sierra County, 144 pp., paper—Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth—Price $2.50, sales tax $0.06	2.56
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, May, June, July, August, September, October, November, December, 1922—Price $0.30, sales tax $0.01	.31
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923—Price $0.30, sales tax $0.01	.31
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy—Price $0.30, sales tax $0.01	.31
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties—Price $0.30, sales tax $0.01	.31
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties—Price $0.30, sales tax $0.01	.31
**July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	----
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties—Price $0.30, sales tax $0.01	.31
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties—Price $0.30, sales tax $0.01	.31
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island — Price $0.30, sales tax $0.01	$0.31
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